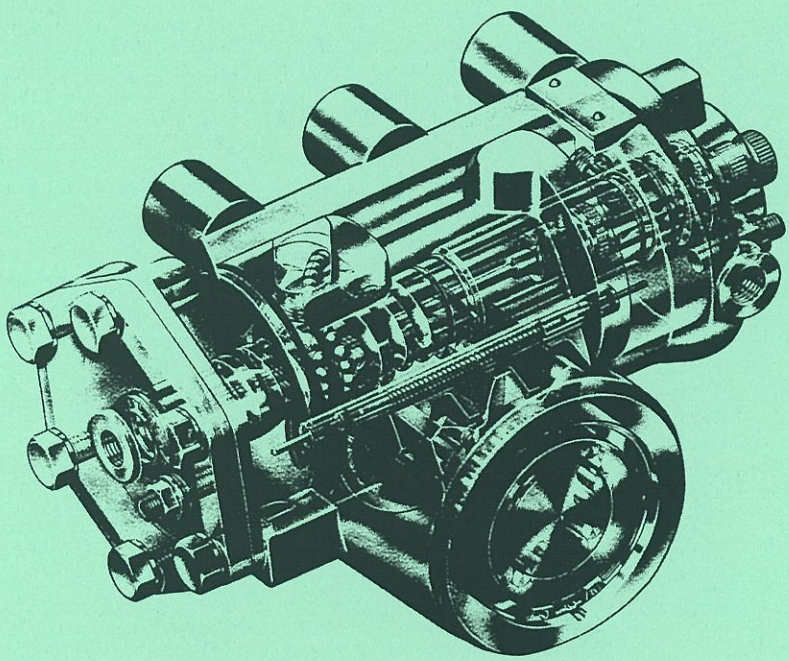
ZF-Servocom®

and ZF Recirculating ball power steering (CV)

Operating, servicing/maintenance and inspection instructions



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→ The present Manual aims to help the user properly to execute the necessary maintenance and repair work on the ZF product.

→ Read the Manual before starting any inspection and repair work.

→ On completion of the maintenance and repair work, the specialist personnel must make certain that the product is once more operating flawlessly.

→ ***Please note that the ZF product must be repaired only in workshops that***

- ☞ ***employ trained personnel***
- ☞ ***have the prescribed equipment, including a test rig, crack detector and special tools***
- ☞ ***use ZF genuine spare parts.***

→ This Manual is only for foremen and fitters who have undergone practical and theoretical training in our Customer Service School. Together with service information bulletins, it is intended to supplement their knowledge.

→ All work carried out on ZF products must be executed with extreme care and diligence. This applies in particular to products and transmission components from vehicles damaged in accidents.

→ The manufacturer does not, of course, accept any liability for damage and its consequences arising from incorrectly or inexpertly executed repairs.

→ This Manual draws attention to notes on safety as follows:

Note: Where incorrect and careless work can cause damage to the product.

Attention: Where incorrect and careless work can lead to personal injury and endanger life.

→ This Manual is not part of the updating service.

→ The contents of the additional service information bulletins must also be observed.

Table of contents:

I. Operation

Attention: important safety information for the driver and workshop personnel

If correctly installed, properly maintained and free of accidents, ZF hydraulic power steering can have a long service life. To ensure complete operativeness, we recommend that the mechanical steering parts are checked (visual examination of all parts, check for cracks in parts under stress) and the seals replaced at the 3rd inspection (does not apply for Servocom steering manufactured after 01.94) (see Section VIII).

The size of the steering and the mechanical steering transmission are selected in consultation with the vehicle manufacturer in such a way that in the event of failure of the hydraulic steering booster, the actuating force to be applied to the steering wheel does not exceed the maximum considered to be reasonable by the law.

Under ECE–R79, this force, which depends on the permissible total weight of the vehicle, is max. 450 N on the steering wheel turn when the vehicle is steered from straight–ahead driving into a circle of radius 20 m. The speed in this case is approx. 10 km/h and the steering action must take no more than 6 seconds.

The driver should know that if the hydraulic power steering suddenly fails, e.g. through failure of the pump drive, his vehicle can still be steered but will require a considerably greater force to be applied for steering. Since such a situation occurs extremely rarely, and then usually completely unexpectedly, the driver may jump to the mistaken conclusion that the steering system is locked. However, this is not the case. The driver must simply apply the necessary force to carry out the steering action.

In order to avoid damage in the steering gear and steering column, the operating force on the steering wheel (diameter 500 mm) when steering while stationary without hydraulic assistance must not exceed 1000 N (approx. 100 kg).

This important safety information is given for the purpose of clarifying the context and preventing the driver making an incorrect diagnosis.

II. Construction and functioning

1 ZF Servocom, Type 8090-98

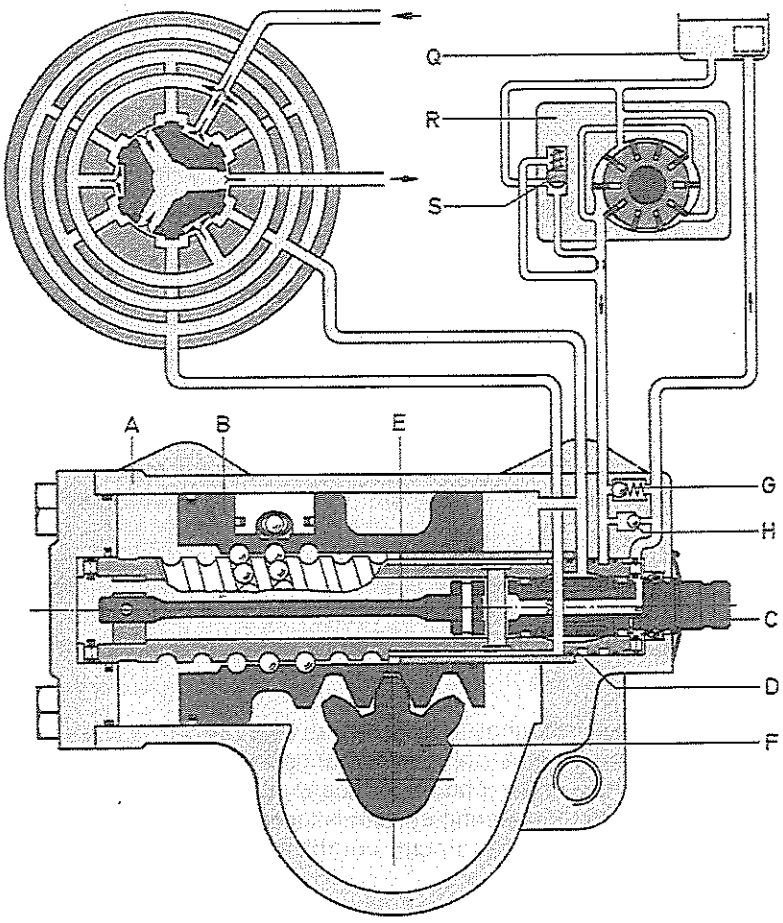
1.1 Construction

The housing of the ZF Servocom contains a control valve, working cylinder and a complete mechanical steering gear.

The pressure oil for the steering is delivered by a motor–driven oil pump which is supplied with oil from an oil tank.

The housing (A) – see also ***Illus. 1*** – is designed as a cylinder for the piston (B), which converts the rotation of the steering shaft (C) and the worm (D) into an axial movement and transfers this to the steering worm sector shaft (F). The toothings of the sector shaft and piston are straight–cut with a high surface quality in such a way that it is only possible to set a unique setting without play on installation in the straight–ahead driving area by means of the two eccentrically designed lateral housing covers.

The piston (B) and worm (C) are connected via a ball chain. When the worm is turned, the balls are collected by a circulating pipe at one end of the chain and fed in again at the other end, thus producing an endless ball chain.



Illus. 1 Valve slide in neutral position

A Housing
B Piston
C Valve slide / steering shaft
D Control sleeve / worm
E Torsion bar
F Steering worm sector shaft

G Pressure relief valve
H Replenishing valve
J Induction port
K Induction port
L Return port
M Return port

N Axial groove
O Axial groove
P Return groove
Q Oil tank
R Wing pump
S Flow control valve

The control valve consists of the valve slide (C) in a needle bearing in the worm, with six control grooves on the circumstance and the control sleeve (D) on the worm, which also has six control grooves. The valve slide, designed with steering shaft connection, turns together with the worm as the steering wheel is turned.

A torsion bar (E), which is pinned with the valve slide (C) and the worm (D), keeps the control valve in the neutral position as long as no opposing force is applied to the steering wheel.
The steering housing contains a pressure relief valve (G) which limits the discharge pressure of the oil pump to the maximum value required. A replenishing valve (H) can also be used, through which oil is sucked from the return if steering is not hydraulically boosted.

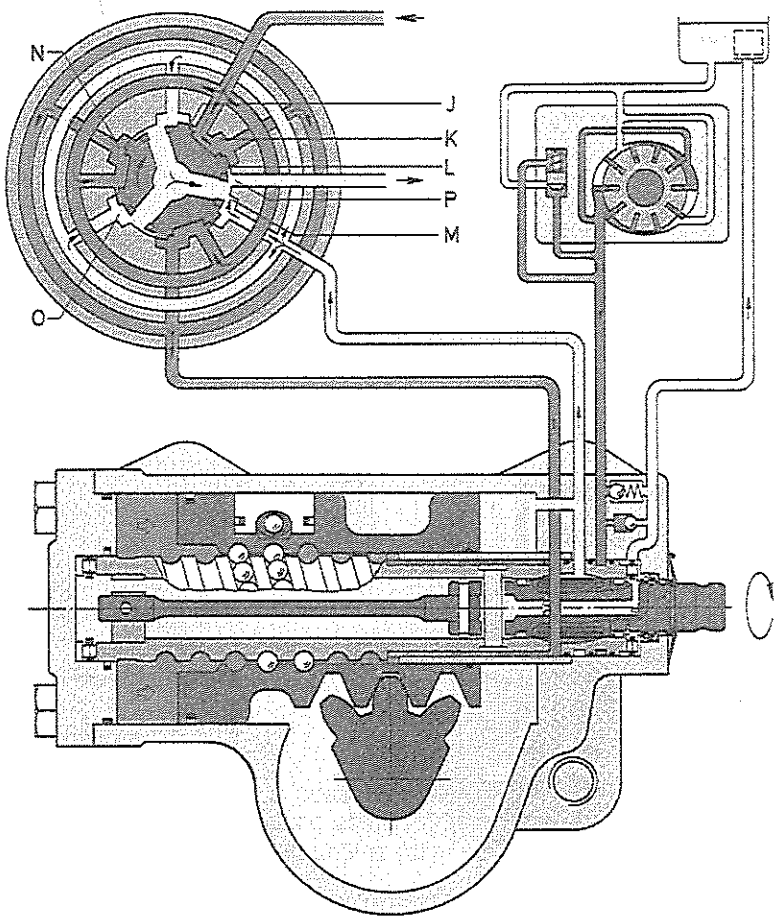
Compared with constant transmission, steering versions with variable transmission are more directly designed in the centre area than outside the centre area. The resulting smaller steering corrections benefit steering behaviour in straight–ahead driving. At the same time, the indirect transmission means that there is a higher hydraulic torque available at the steering arm in parking movement.

If the hydraulic assistance fails, the operating forces on the steering wheel are correspondingly lower in this area. This is achieved through a piston/steering worm sector shaft toothing with differing modulus and angle of pressure.

1.2 Function

Upon transfer of a torque from the steering shaft to the worm, or vice versa, the torsion bar is deformed in the elastic area so that there is torsion between the valve slide and the control sleeve. The control grooves of the valve slide are thereby displaced from the central (neutral) position compared with the control grooves of the control sleeve.

When the steering wheel is released, the torsion bar ensures that the valve is returned to the neutral position.



Illus. 2
Valve slide in working position
Steering wheel turned in clockwise direction

operating pressure

return flow pressure

J Induction port
K Induction port
L Return port
M Return port

N Axial groove
O Axial groove
P Return groove

The 3 functional diagrams of ***Illus. 1*** to ***3*** show valve and oil flow in a simplified way for ease of comprehension. These diagrams also show the valve in cross–section so that the connections from the control valve to the cylinder compartments and the functioning of the valve can be shown schematically.

The pressure oil flows into the ring–shaped groove of the control sleeve. It is fed to the arch–shaped control grooves of the internal valve slide through three symmetrically arranged radial holes. The position of the control grooves in the valve slide and control sleeve is set in such a way that if the valve is in a neutral position, the pressure oil can run into the axial grooves (N and O) of the control sleeve, which are also arch–shaped, through the induction ports (J and K). From there the oil is released to each side of the working cylinder via radial holes. As long as the steering valve is in the neutral position, the oil can run into both sides of the working cylinder and to the three return grooves (P) in the valve slide, from where it returns to the oil tank.

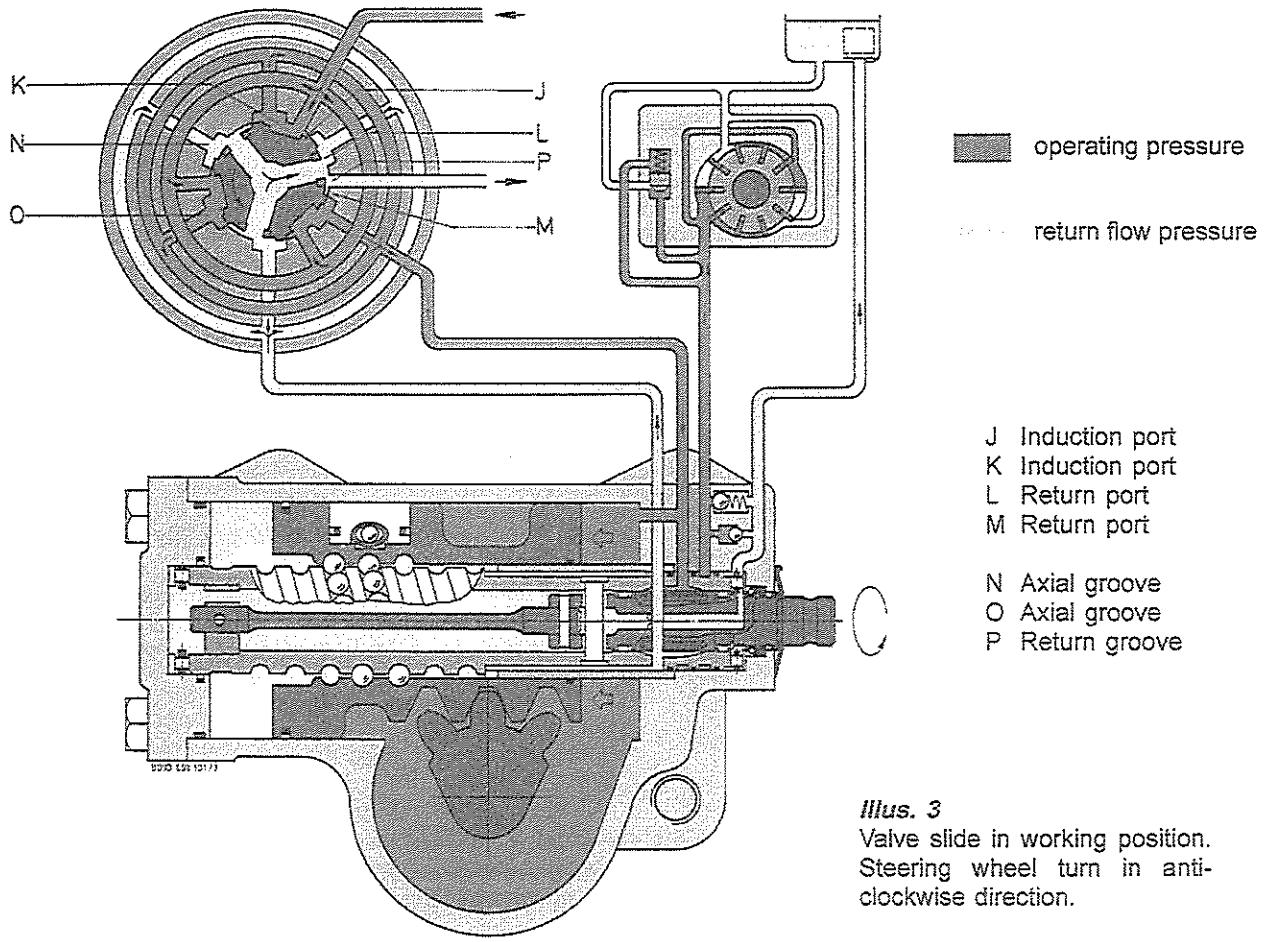
When the steering wheel is turned in a clockwise direction, the piston with a right–handed thread is pushed to the right ***(Illus. 2)***. Since the movement of the piston is to be assisted through pressure oil, the oil must now be directed to the left cylinder side.

The control grooves of the valve slide are pushed in a clockwise direction and the induction ports (K) are opened further for the pressure oil supply. However, the induction ports (J) close and block the supply of pressure oil to the axial grooves (O) and the control sleeves.

In the position of the valve described in ***Illus. 2***, the pressure oil flows through the induction ports (K) into the axial grooves (N) of the control sleeve and from there reaches the left cylinder via the planetary thread, so that piston movement is ensured for the hydraulic assistance. The closed induction ports (J) prevent the oil flowing to the oil tank.

The oil from the right cylinder side is compressed. It flows via the opened return ports (M) to the return grooves (P) of the valve slide. From here constant return to the oil tank is ensured through the centrally positioned oil hole in the valve slide.

If the steering wheel is turned in the opposing direction ***(Illus. 3)***, the piston of the working cylinder moves to the left and should be assisted through pressure oil in the right cylinder. The control grooves of the valve slide are pushed in an anticlockwise direction and let the pressure oil flow through the opened induction ports (J) into the axial grooves (O), from where connection to the right cylinder is established. The oil from the left cylinder flows via the planetary thread and the opened return ports (L) to the return grooves (P) of the valve slide. Access to the oil tank is open via the centrally positioned oil hole in the valve slide.



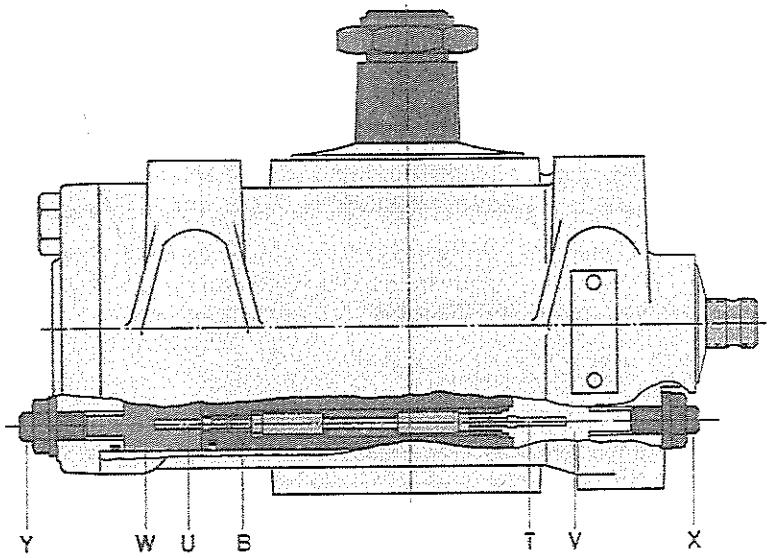
Illus. 3
Valve slide in working position. Steering wheel turn in anti-clockwise direction.

1.3 Functioning of the hydraulic steering limiter

The hydraulic steering limiter prevents steering to the wheel locks at full hydraulic pressure. It serves to protect the pump and steering linkage and prevents high oil temperatures.

A double–acting steering limiter valve with spring–weighted valve pins (T and U) extending beyond the right and left piston faces is located in the piston (B) along its longitudinal axis *(Illus. 4)*.

Illus. 4 Steering limiter valves closed



T right valve pin of steering limiter valve
U left valve pin of steering limiter valve

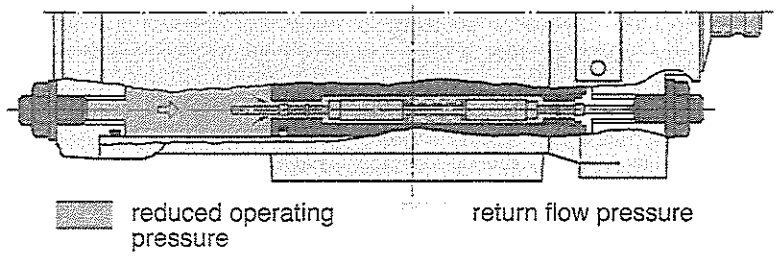
V right cylinder compartment
W left cylinder compartment

X right setting screw
Y left setting screw

When the piston is pushed to the right or left towards the final stop, the valve pins (T and U) are actuated by the setting screws (X and Y) fixed in the housing and cylinder cover. The steering limiter valve remains closed until a valve pin contacts the setting screw.

When the piston moves to the right, for example ***(Illus. 5)***, the right valve pin (T) contacts the setting screw (X) before the piston limit position is reached. The valve pin (U) is thereby pushed by the pressure oil, whereby the oil flows from working cylinder compartment (W) into working cylinder compartment (V) and can reach the return. If the piston moves to the left, the process is reversed.

Illus. 5 Piston moves to the right. Right valve pin opened. Oil pressure greatly reduced.



When the steering limiter valve is opened, the steering can continue to be turned with increased force and greatly reduced hydraulic assistance up to the wheel lock or the stop in the steering.

1.4 Setting the mechanically adjustable hydraulic steering limiter, type 8090–98

Note:
In principle, the hydraulic steering limiter is first set by the manufacturer in the test bay according to the engineering instructions of the vehicle companies.
Further setting is carried out after the steering has been installed in the vehicle and in the prescribed inspections by means of a manometer. Adhere to the setting instructions of the vehicle manufacturer.

Setting the hydraulic steering limiter in vehicles using a manometer:

A manometer (pressure range up to 250 bar or hydraulic steering tester) is screwed into the pressure line between the pump and the steering system ***(Illus. 6)*** and the steering axle, if designed as a rigid axle, is relieved through jacking–up.

Attach jack to axle. If the vehicle has independent suspension, the steered wheels must stand on rotary tables for setting of the hydraulic steering limiter; in any case, the steering axle must be loaded in order to compensate approximately for possible deflection errors in measurement.

Turn steering up to wheel lock with engine running at idle speed, oil temperature of steering system above **50°C or 30°C**, without exerting great force.

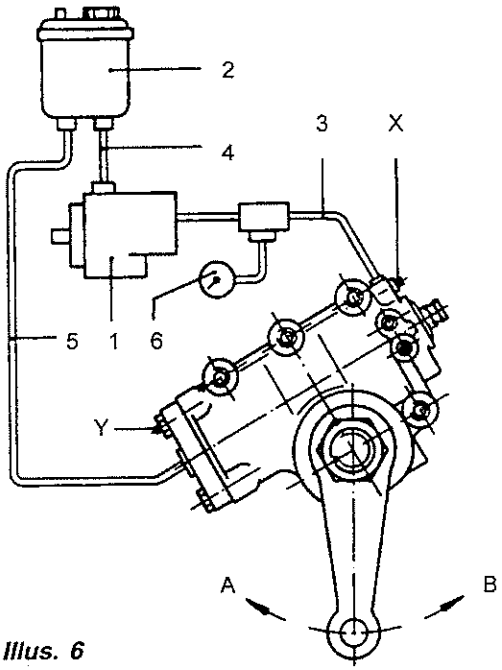
Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the self–aligning force of the steering valve until a fixed steering wheel lock is achieved.

An actuating force on the steering wheel of 100 – 200 N is required to do this.

If the steering limiter is set correctly and the flow rate while the engine is at idle speed does not exceed 16 dm^3/min, e.g. with steering systems with an additional working cylinder, the manometer must now show an oil pressure of

40 to 45 bar at an oil temperature of 50°C, or
45 to 50 bar at an oil temperature of 30°C.

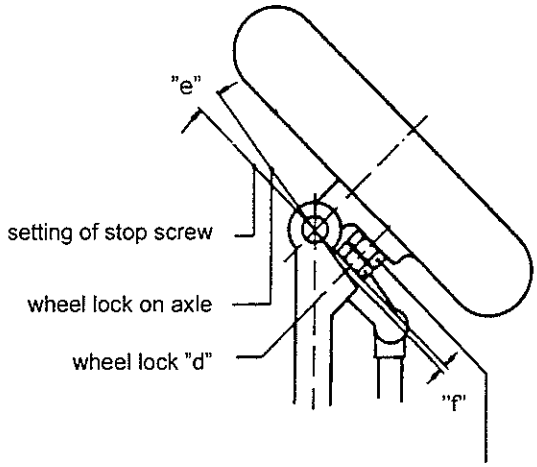
The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), *see Illus. 26*.



Illus. 6

X Setting screw of hydraulic steering limiter for steering arm deflection in direction "A"

Y Setting screw of hydraulic steering limiter for steering arm deflection in direction "B"



Illus. 7 setting screw "c"

Illus. 7 shows the distance "f" which should exist between the wheel lock parts upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a distance

1 Pump
2 Oil pump
3 Pressure line
4 Suction line
5 Return line
6 Manometer

If the above examination shows that the desired pressure drop has not been achieved, the reason may be that the flow rate is too great (above 16 dm^3/min) or the oil temperature too low. In this case the flow rate of the pump with the engine at idle speed must be measured or the oil temperature increased. For steering systems with higher flow rates, the following setting values apply:

above 16 dm^3/min:	50 to 55 bar at 50°C
	55 to 60 bar at 30°C
above 20 dm^3/min:	70 to 75 bar at 50°C
	75 to 80 bar at 30°C

To make corrections, release the corresponding lock nut and screw the setting screw (X or Y) in or out ***(Illus. 6)***. Release the steering wheel at the same time, so that only the flow pressure builds up during this operation. Then tighten lock nut with 30 Nm.

Attention:
During the setting as soon as in the installed condition it must be secured that the setting screws (x and y) are at least screwed in 3 pitches. Otherwise the caution is present that the screws will be exploded out in the case of maximum pressure.

The second wheel lock is set in a similar fashion.

The setting screw (X) in ***Illus. 6*** must be adjusted if the steering column is moved towards "A" according to ***Illus. 6***. In the same way, setting screw (Y) is adjusted if the steering column turns towards "B".

After this setting, the hydraulic assistance should be active until the wheel lock is reached. To check the setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

If the pressure falls too early or too late when the steering column is turned towards "A" or "B", the setting screws (X or Y) must be twisted as described below.

If a higher pressure is measured, the corresponding setting screw must be **screwed in** again (clockwise).

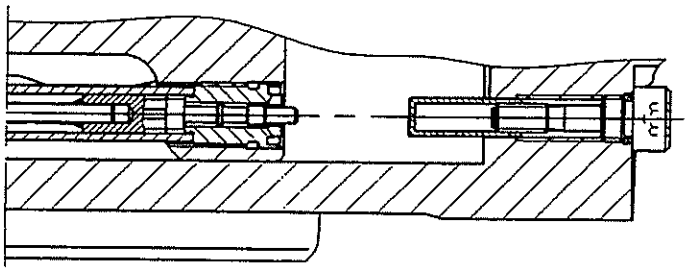
If a lower pressure is measured, the corresponding setting screw must be **screwed out** again (anticlockwise).

Check:
To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

1.5 Automatically adjustable hydraulic steering limiter, type 8090–98 (visible externally by hexagon instead of lock nut)

Attention:

Steering systems with automatically adjustable steering limiters must not be mechanically turned to the limit positions if the steering linkage has been removed or the system dismantled. The sliding sleeves would then be pushed into the maximum possible cut–off position and automatic setting in the vehicle would only be possible with new sliding sleeve assemblies (X or Y) ***(Illus. 8)***. If necessary, fit new sliding sleeve assemblies.
Sliding sleeve assemblies and normal setting screws are not interchangeable.



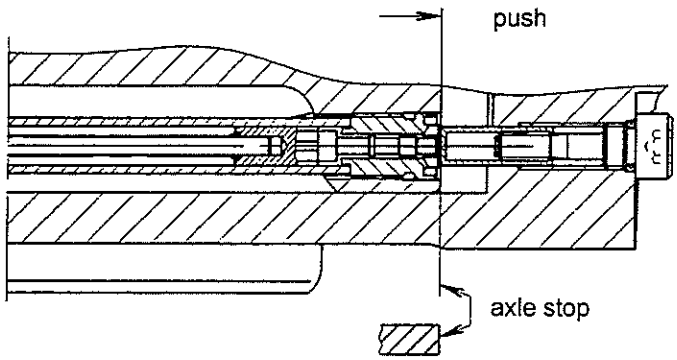
Illus. 8 Starting position of sliding sleeves not yet set

1.5.1 Functioning of automatically adjustable hydraulic steering limiter

With the automatically adjustable hydraulic steering limiter, screws (X and Y) with pressed–on sliding sleeves are located in place of setting screws.
These function in the same way as with the manually adjustable hydraulic steering limiter. In the limit positions, the valve piston tappets meet the sliding sleeves and open the steering limiter valves (U and T). The opening point is determined by the position of the sliding sleeves on the screws.

1.5.2 Setting

Note:
Setting ***(Illus. 9)*** is only possible after the steering system has been installed in the vehicle. The steering linkage and the axle stops must be mounted and set.



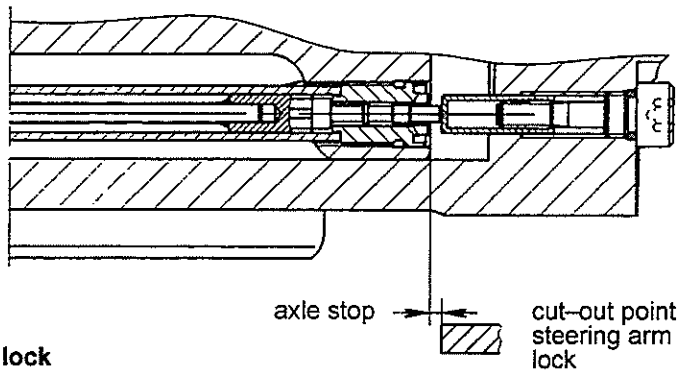
Illus. 9 Setting process

Positioning the sliding sleeves

When the above conditions have been met, the steering wheel must be turned to the maximum wheel lock with or without hydraulic assistance. This causes the piston to push the sliding sleeve on the screw to the cut–out position ***(Illus. 9)***. The steering limiter valve is permanently open during this setting process, which is why the steering wheel can only be turned with increased force whether or not there is hydraulic assistance. In order to allow mechanical steering and roughly compensate for errors of deflection which may occur in measurement, for vehicles with independent suspension the steered wheel must be on rotary plates; if the steering axle is designed as a rigid axle, it is sufficient to support the axle with a jack. The steering axle must be loaded in any case.

This process must be carried out in both directions of rotation until a fixed stop has been reached. The sliding sleeves are automatically returned to the correct cut–out position ***(Illus. 10)***.

Illus. 10



Left steering limiter valve open, oil pressure greatly reduced

1.5.3 Correcting the steering arm steering lock

To **increase the steering arm steering lock** (the space between the wheel lock parts is too great): carry out setting as described above.

To **reduce the steering arm steering lock** (the oil pressure at the axle stop does not fall to the value given in Section II Para. 1.4):

Fit new sliding sleeves assembly (20 or 128) [1].

Attention:
It is not permitted to pull the sliding sleeve back to the press fit of the screw.

Tightening torque for sliding sleeve assembly: 15^{+3} Nm.

[1] The numbers in square brackets refer to the key to numbers in figures at the end of the instructions.

2 ZF recirculating ball power steering systems, type 8033–46

2.1 Construction:

The housing contains a control valve, working cylinder and a complete mechanical steering gear. The pressure oil for the steering is delivered by a motor–driven pressure oil pump which is supplied with oil from an oil tank. The housing (1 or A) is designed as a cylinder for the piston (2 or B) which carries out the task of converting the rotation of the steering shaft into an axial movement and transferring this to the steering worm sector shaft (5 or D). To ensure perfect power transmission, the toothing of the sector shaft is designed in such a way that when the shaft transverse to the piston is adjusted axially, any possible backlash is eliminated. This free play is adjusted using a setting screw and this can be carried out in the vehicle (see Section IV).

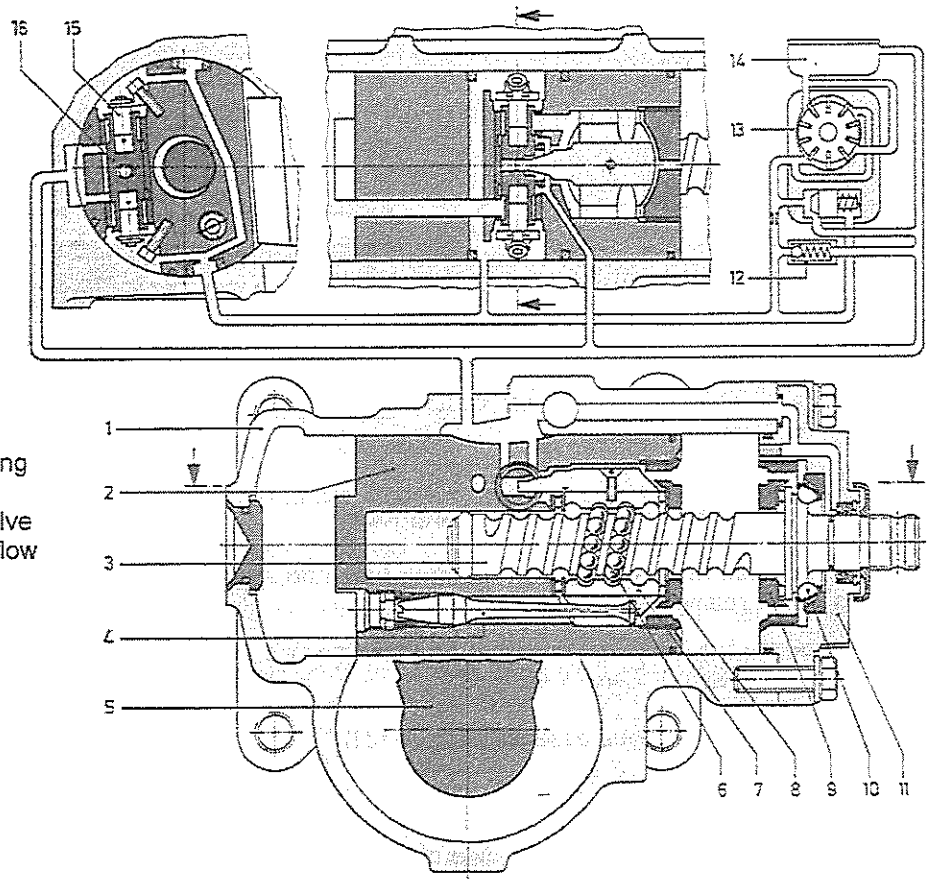
The threaded hole of the piston is connected to the worm (3 or E) via a ball chain. When the worm is turned, the balls (6 or F) on one end of the chain are taken up by a circulating pipe and fed back to the other end, thus forming an endless ball chain. The control valve is transverse to the piston. It comprises a valve piston (16) and two fixed recoil pistons (15). One finger of the steering nut (7) meshes with great accuracy into the hole of the valve piston.

2.2 Functioning:

In order to obtain hydraulic assistance while steering, which should be started when the steering wheel is turned, the valve piston must be displaced from the neutral position.

Illus. 11

Recirculating ball power steering, type 8043, steering valve centralised through flexible rod, neutral position



1 Housing
2 Piston
3 Worm
4 Flexible rod
5 Sector shaft
6 Balls
7 Steering nut
8 Threaded ring
9 Threaded ring
10 Angular ball bearing
11 Cover
12 Pressure relief valve
13 Wing pump with flow control valve
14 Oil tank
15 Recoil piston
16 Valve piston

The valve is kept in the neutral position by means of a spring element which may, according to design, be a centralizing spring, a leaf spring or a flexible rod. For this reason force must be applied in order to overcome the pretension.

The piston, interlocked with the sector shaft and the steered wheels, resists any rotary motion. During steering, the steering nut is therefore stressed via the worm and ball chain in the circumferential direction and the elastic threshold overcome. The pressure oil flowing into the steering housing from the motor–driven pump is then directed into the cylinder from which the steering process is being hydraulically assisted.

The pressure oil flows laterally underneath the valve into a longitudinal groove of the piston. To provide a balance of pressure, it is led into an equally large longitudinal groove on the opposite side and passes through transverse holes to reach the faces of the valve piston which are separated from the cylinders by seals. With the valve in a neutral position, the oil flows towards the centre of the valve piston after flowing through feed and return leading edges and from there upwards into a recess of the piston through the corresponding holes. From here it flows out into the return ***(Illus. 11)***. When the valve is displaced, the pressurized side of the piston is separated from the return and the opposite side of the cylinder is connected with the return. The steering valve is fitted with 2 recoil pistons, whose function is to make it more difficult to displace the valves from the neutral position through the oil pressure. The actuating force on the steering wheel thus rises in proportion to the forces acting on the wheels. Steering systems in which a proportional rise of the actuating force is only desired up to a predetermined oil pressure are fitted with an actuating force limiting valve. The valve fitted in the recoil valve ensures that the force on the steering wheel does not rise much further after the cut–off pressure has been reached.

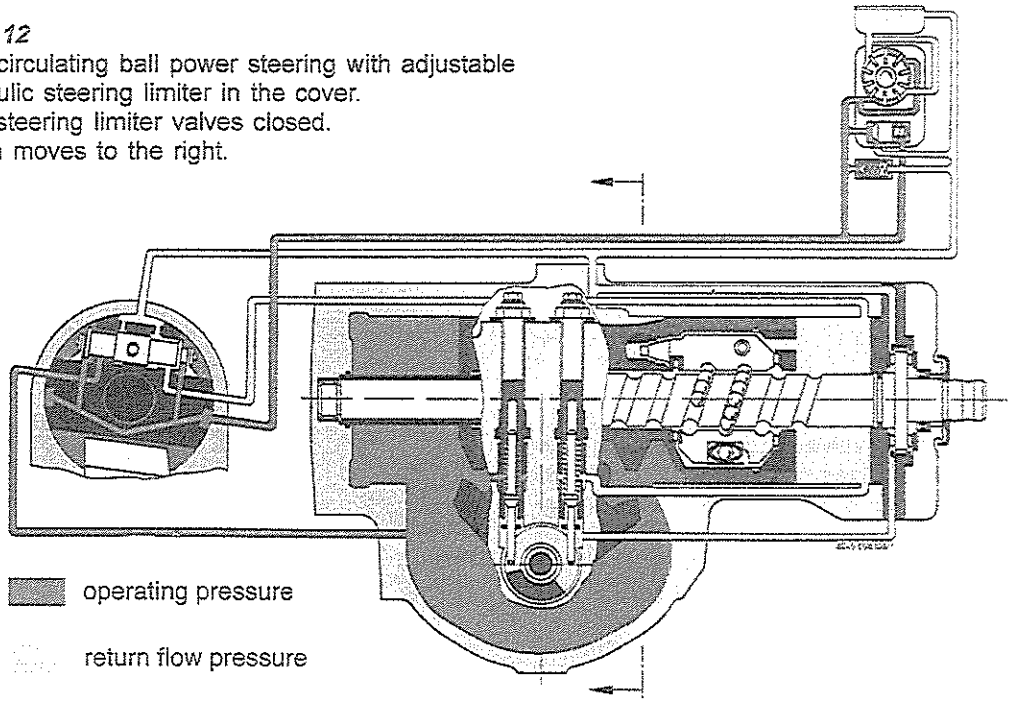
Action of the recoil pistons:
These have a floating bearing in the hole of the valve piston. But they are held axially and secured through connection with retaining plates. The outer faces of both pistons are constantly charged with pressure oil, whereas only one of the inner faces in the working position of the valve is charged with pressure oil. The same applies for the faces in the holes of the valve piston. This produces a force which tries to bring the valve piston back into the neutral position. This property is called "hydraulic reaction".

2.3 Functioning of the hydraulic steering limiter

2.3.1 Adjustable steering limiter

The housing cover is fitted with two valves (55), in each of which 1 valve piston is guided ***(Illus. 12)***. Both valve pistons are actuated by the cam located on the face of the sector shaft. When the sector shaft is turned, the valves remain closed until the cam of the sector shaft meets a valve piston, lifts it and thereby opens the valve ***(Illus. 13)***. The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.

Illus. 12
ZF recirculating ball power steering with adjustable hydraulic steering limiter in the cover.
Both steering limiter valves closed.
Piston moves to the right.

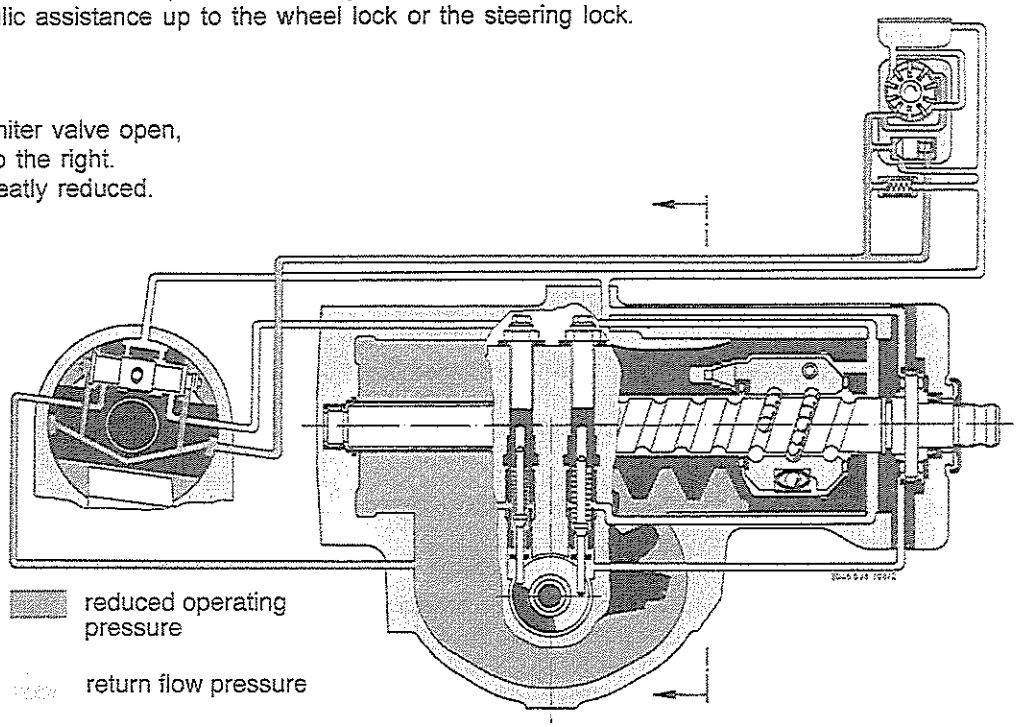


When the sector shaft is turned in a clockwise direction (see ***Illus. 13***, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

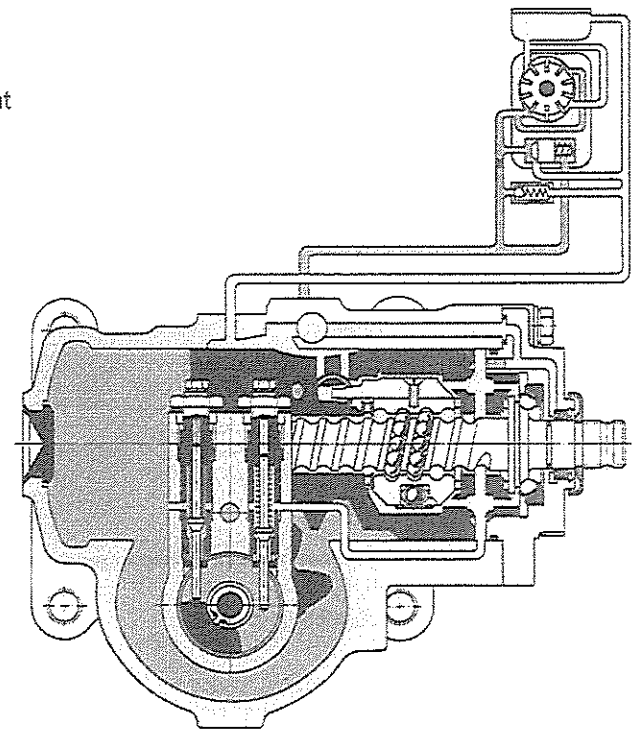
When the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return.

If the steering limiter valve is open, the steering can be turned further with increased force and greatly reduced hydraulic assistance up to the wheel lock or the steering lock.

Illus. 13
Left steering limiter valve open,
piston moves to the right.
Oil pressure greatly reduced.



Illus. 14
Recirculating ball power steering, type 8043.
Oil is fed to unpressurized cylinder compartment via two steering limiter valves.



When the left valve piston is actuated, the pressure oil flows out of the left cylinder into the compartment below the steering limiter valve. The oil pressure building up there lifts the right valve piston from its seat against the spring resistance and permits access to the right cylinder compartment connected with the return.

2.3.2 Non–adjustable steering limiter

a) Steering version 8036 and 8038

The piston head is fitted with a ball valve which is always closed because of the oil pressure in the left or right working cylinder. Not until just before the piston reaches the housing on the left or the worm on the right is the valve actuated by a pin and pressure oil allowed to flow to the return.

b) Steering version 8033 and 8037

When the piston moves to the left, the pressure oil can flow into the housing return channel before the stop is reached via a piston hole located at right angles to the piston axis. When the piston moves to the right, the edge of the piston head releases the return channel in the housing.

2.4 Setting the hydraulic steering limiter, type 8033–46

Note
In principle, the hydraulic steering limiter is first set by the manufacturer in the test bay according to the engineering instructions of the vehicle companies.
Further setting is carried out after the steering is installed in the vehicle and on the prescribed inspections by means of a manometer. Adhere to the setting instructions of the vehicle manufacturer.

Setting the hydraulic steering limiter in the vehicle using a manometer:

A manometer (pressure range up to 250 bar or hydraulic steering tester) is screwed into the pressure line between the pump and the steering gear ***(Illus. 15)***. The steering axle, if designed as a rigid axle, is relieved through jacking. Adhere to instructions of the vehicle manufacturer. If the vehicle has independent suspension, the steered wheels must stand on rotary tables for setting of the hydraulic steering limiter; in any case, the steering axle must be loaded in order to compensate roughly for possible deflection errors in measurement. Without exerting great force, turn steering up to wheel lock with engine running at idle speed, oil temperature of steering system above 50°C.

Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the resetting force of the steering valve until a fixed steering wheel lock is achieved. To reach this, and depending on the size of the hydraulic reaction, a peripheral force on the steering wheel of approx. 100 – 200 N is required. If the steering limiter is set correctly, the manometer must now show an oil pressure of between **30 and 35 bar**. To make corrections, release the lock nut (a1 or b1) and screw the corresponding valve sleeve (a2 or b2) in and out. Release steering wheel at the same time, so that only the flow pressure builds up during this work. Then tighten lock nut a1 or b1.

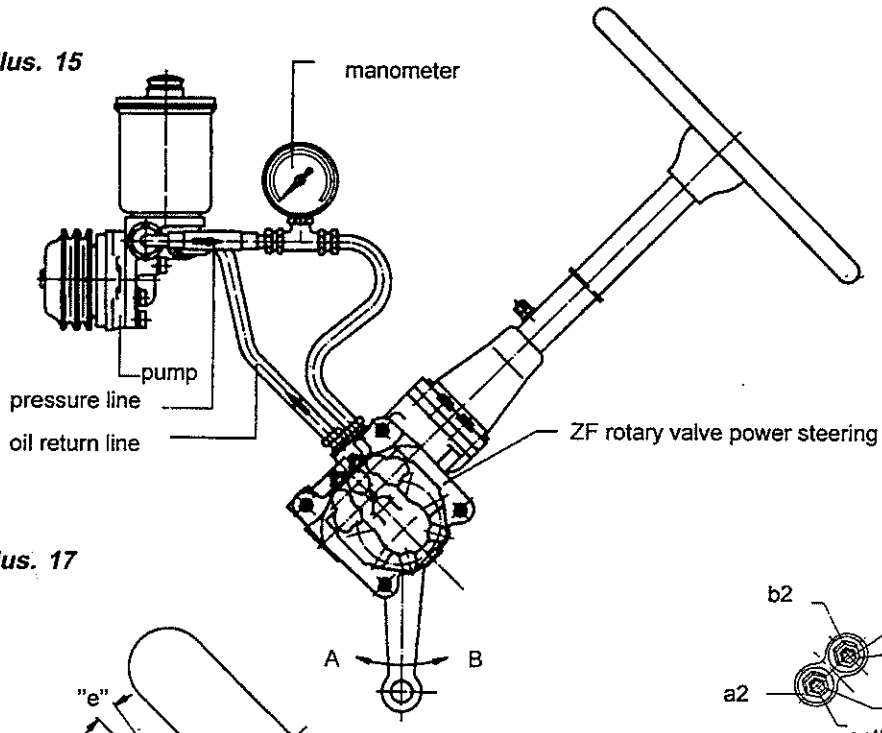
Tightening torque for lock nut: 25 to 35 Nm.

The second wheel lock is set in a similar fashion. The valve (a2) and lock nut (a1) in ***Illus. 16*** must be adjusted if the steering arm is moved towards "A" according to ***Illus. 15***. In the same way, valve (b2) and lock nut (b1) are adjusted if the steering arm turns towards "B".

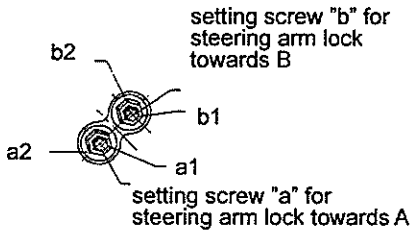
The vehicle manufacturer may prescribe a mode of setting that differs from the abovedescribed (e. g. insertion of a spacer), ***see Illus. 26***.

After this setting, the hydraulic assistance should be active until the wheel lock is reached. To check the setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

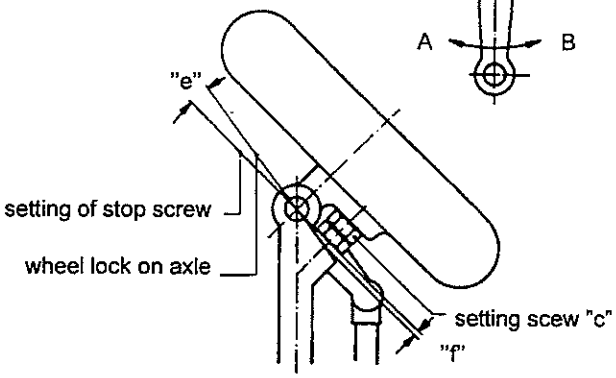
Illus. 15



Illus. 16



Illus. 17



Illus. 17 shows the distance "f" which should exist between the wheel lock parts upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a distance.

In this position a distance should exist between the wheel lock parts ***(see Illus. 17)***, provided that the vehicle manufacturer prescribes a distance.

If the pressure falls too early or too late when the steering arm is turned towards "A" or "B", the valve sleeves (a2 and b2) must be twisted as described below.

If a pressure greater than 35 bar is measured, the corresponding steering limiter valve (55) must be **screwed** further **into** the cover (clockwise).

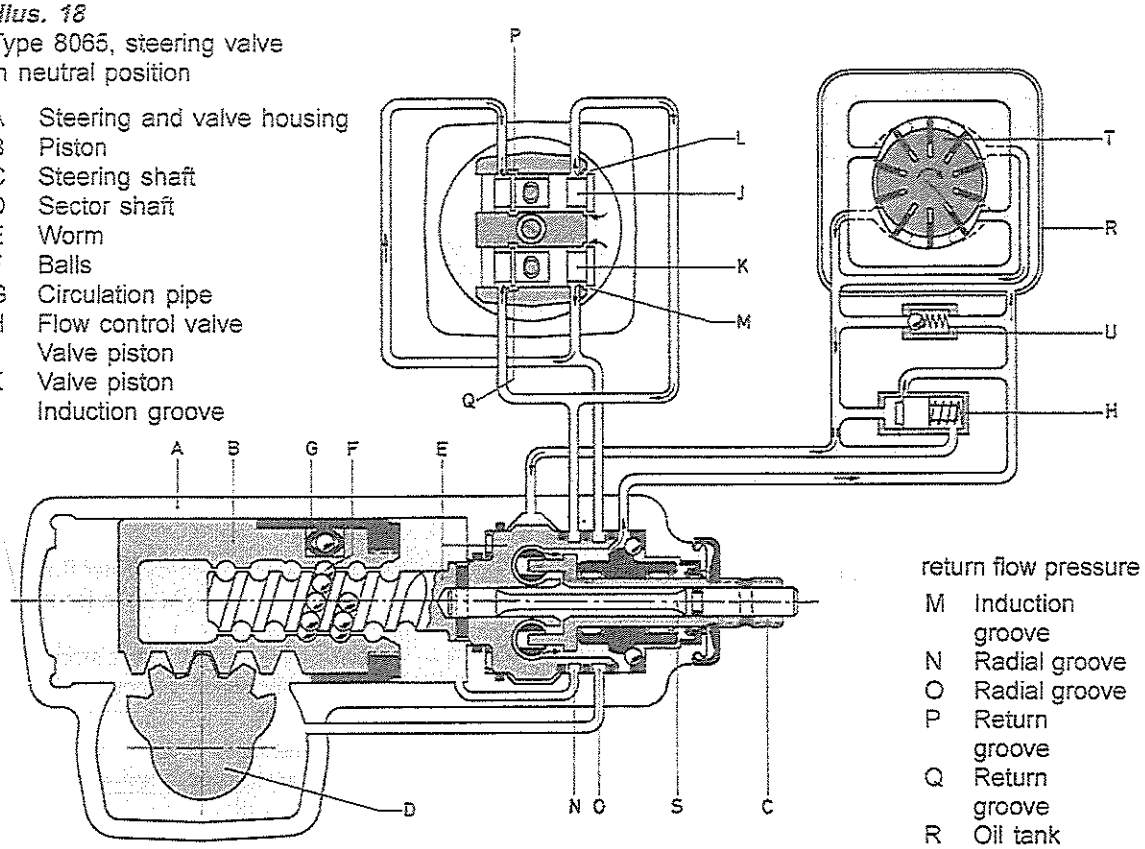
If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (55) must be **screwed** further **out** (anticlockwise).

Check:
To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

3. ZF recirculating ball power steering, type 8056–70

Illus. 18
Type 8065, steering valve in neutral position

A Steering and valve housing
B Piston
C Steering shaft
D Sector shaft
E Worm
F Balls
G Circulation pipe
H Flow control valve
J Valve piston
K Valve piston
L Induction groove



return flow pressure

M Induction groove
N Radial groove
O Radial groove
P Return groove
Q Return groove
R Oil tank
S Torsion bar
T Pressure oil pump
U Pressure relief valve

3.1 Construction

Design as for steering types 8033–46, but with a different steering valve. The worm head accommodates two valve pistons (J and K) lying transverse to the worm axis, and these rotate together with the worm and the steering shaft in the valve housing of the steering system when the steering wheel is turned. The valve pistons have a cross hole in the centre in which two arms of the steering shaft (C) engage. There is therefore a connection without play between the valve pistons and the steering shaft, which is also connected to the worm via a torsion bar.

3.2 Functioning

When the steering wheel is turned in a clockwise direction, the piston with left–handed thread is pushed to the right. Since the movement of the piston is to be assisted by pressure oil, the oil must now be fed to the right cylinder side. The upper valve piston (J) is pushed to the right and the induction port (L) for the pressure oil supply opened further. By contrast, the lower valve piston (K) moves to the left and the pressure oil supply is interrupted by the closing of the induction groove (M). The return grooves (P and Q) can be seen in the upper valve representation for both valve pistons on the left of the valve piston centre. The pressure oil line of the upper valve piston is connected to the left radial groove (N) in the head of the worm and to the return groove of the lower valve piston (Q). Likewise, the pressure oil line of the lower valve piston is connected to the right radial groove (O) of the worm and the return groove (P) of the upper valve piston.

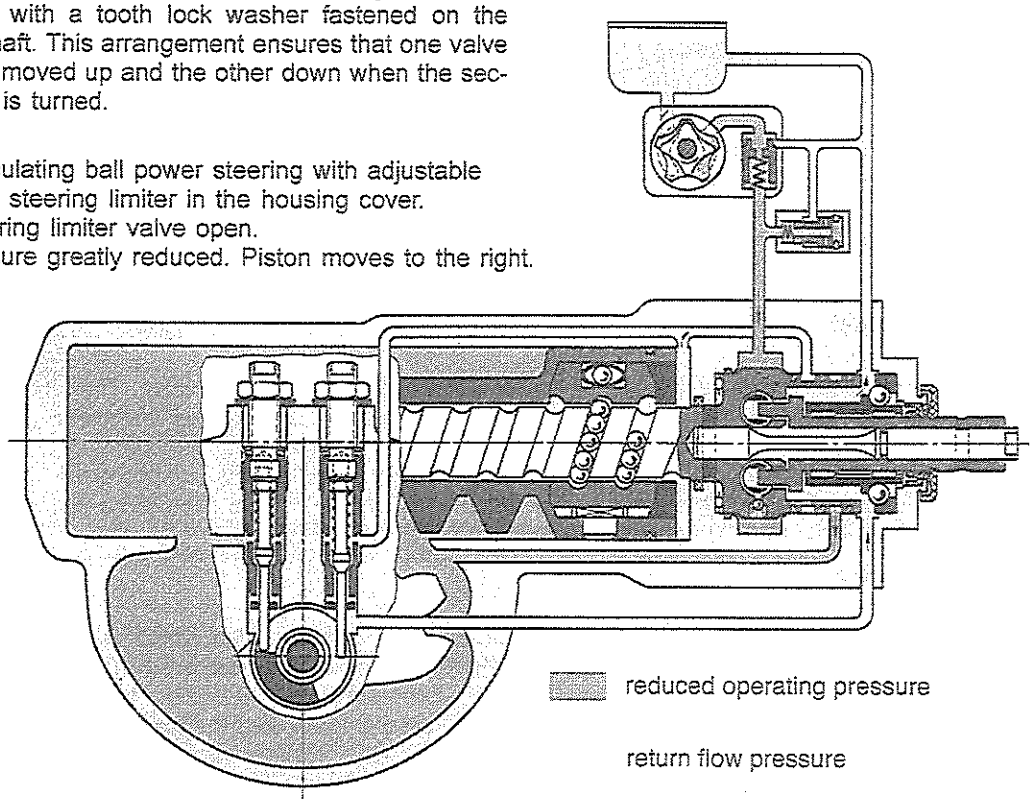
The pressure oil flows through the induction groove (L) of the upper valve piston to the left radial groove (N) and from there into the right cylinder, so that the piston movement is hydraulically assisted. However, at the same time the pressure oil reaches the return groove (Q) of the lower valve piston, but this is closed and blocks the return of this oil. The oil from the left cylinder is compressed. It flows via the radial groove (O) in the worm to the induction groove (M) of the lower valve piston. This is closed. However, at the same time the oil flows further to the return groove (P) of the upper valve piston, which is open, thus allowing the oil to reach the valve piston centre. From here constant return to the oil tank is guaranteed, as the diagram of the steering system ***(Illus. 18)*** shows.
If the steering wheel is turned in the opposite direction, the piston moves to the right ***(Illus. 19)*** and should be hydraulically assisted through pressure oil in the left cylinder. The lower valve piston is pushed to the right and allows the pressure oil to reach the right radial groove (O) in the worm, from where connection to the left cylinder is established. The pressure oil is also allowed to flow to the return groove (P) of the upper valve piston, but this is closed and prevents the oil flowing out to the valve piston centre. The oil from the right cylinder flows via the left radial groove (N) in the worm to the return groove (Q) of the lower valve piston, which is open, thus permitting access to the valve piston centre and from there to the oil tank.

3.3 Functioning of the hydraulic steering limiter

The housing cover is fitted with two valves, in each of which 1 valve piston is guided. Both valve pistons are actuated by the cam located on the face of the sector shaft (60). When the sector shaft is turned, the valves remain closed until the cam of the sector shaft meets a valve piston, lifts it and thereby opens the valve ***(Illus. 19)***.

The valves are connected to the return by holes. The pressure oil of the left cylinder flows through a hole in the housing cover to the left valve, while the pressure oil of the right cylinder reaches the right valve through a hole in the housing.
If the steering limiter valves are located in the housing – ***see Illus. 20*** – the valve pistons in the two valve sleeves are connected to a toothed quadrant by means of connecting elements. The toothed quadrant is swivel mounted in the housing cover and engages with a tooth lock washer fastened on the sector shaft. This arrangement ensures that one valve piston is moved up and the other down when the sector shaft is turned.

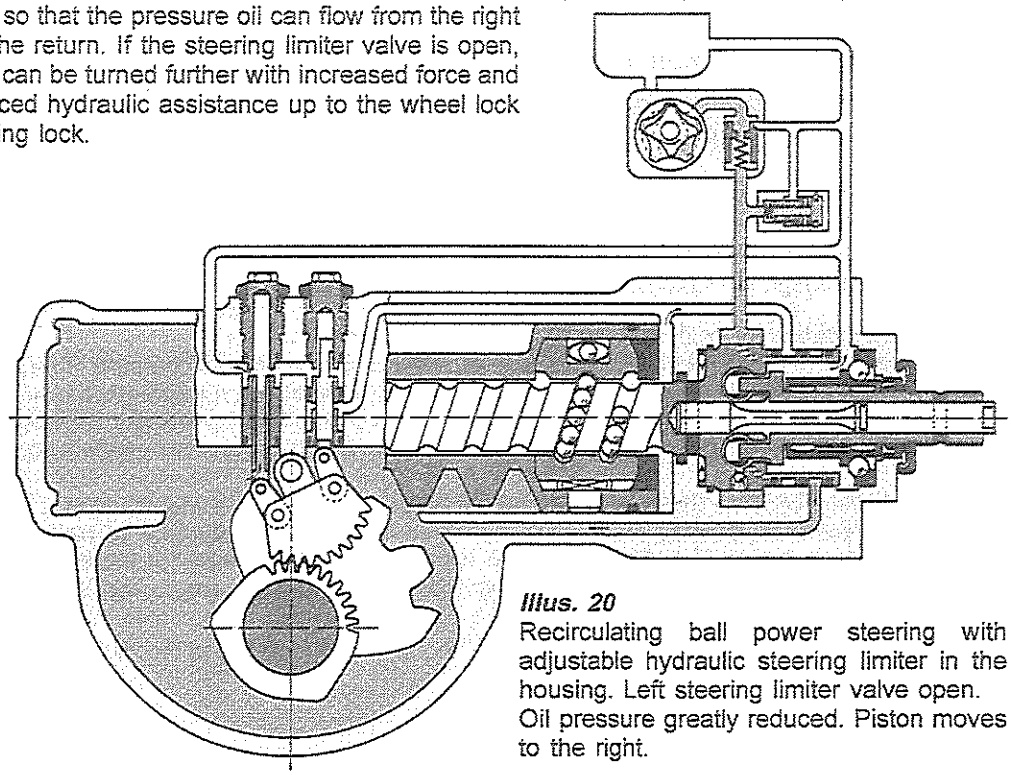
Illus. 19
ZF recirculating ball power steering with adjustable hydraulic steering limiter in the housing cover.
Left steering limiter valve open.
Oil pressure greatly reduced. Piston moves to the right.



When the sector shaft is turned in an anticlockwise direction (see ***Illus. 19***, piston moves to the right), the left valve piston is actuated according to a defined steering arm lock, which can be altered by screwing the valve in or out. The pressure oil can then flow through the valve seat from the left cylinder

compartment to the return. The position of the steering valve is not changed. The right steering limiter valve remains closed during this process.

If the sector shaft is turned in an anticlockwise direction, the right valve opens according to a predetermined path, so that the pressure oil can flow from the right cylinder to the return. If the steering limiter valve is open, the steering can be turned further with increased force and greatly reduced hydraulic assistance up to the wheel lock or the steering lock.



Illus. 20
Recirculating ball power steering with adjustable hydraulic steering limiter in the housing. Left steering limiter valve open. Oil pressure greatly reduced. Piston moves to the right.

3.4 Setting the hydraulic steering limiter, type 8056–70

Install manometer (pressure range up to 250 bar or hydraulic steering tester) as described under Section 2 for ZF rotary valve power steering ***(Illus. 15*** to ***17)*** and carry out setting.

If the pressure falls too early or too late when the steering arm is turned towards "A" or "B", the valve sleeves (a2 and b2) must be twisted as described below.

a) For steering systems in which the steering limiter valves are installed in the housing cover ***(Illus. 19)***: **If a pressure greater than 35 bar is measured**, the corresponding steering limiter valve (36) must be **screwed** further **into** the cover (clockwise).

   If a pressure lower than 30 bar is measured, the corresponding steering limiter valve (36) must be **screwed** further **out** (anticlockwise).

b) For steering systems in which the steering limiter valves are installed in the housing (Illus. 20):
   If a pressure greater than 35 bar is measured, the corresponding valve sleeve (36) must be **screwed** further **out** (anticlockwise).

   If a pressure lower than 30 bar is measured, the corresponding valve sleeve must be **screwed** further **into** the housing (clockwise).

Tighten lock nut a1 or b1 with **25 to 35 Nm**.

Illus. 17 shows the distance "f" which should exist between the wheel lock parts and be approx. 2mm upon response of the hydraulic steering limiter, provided that the vehicle manufacturer prescribes a setting with spacer.

Check:
To check this setting appropriately, turn the steering wheel, while driving the vehicle slowly and under normal load, until the hydraulic assistance is disconnected.

III. Maintenance, oil change and ventilation

Note:
When the steering system is being filled with hydraulic fluid, there is a danger that particles of dirt will get into the steering oil circuit. In order to avoid malfunctions caused by foreign bodies in the system, the utmost cleanliness must be ensured both on first filling and on refilling.

Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

When cleaning the vehicle with steam–cleaning devices:
Do not direct the steam cleaner straight onto exposed sealing parts of the aggregates belonging to the steering system. Water penetrating protecting caps, shaft seals or seals of universal joints can cause corrosion damage.

Recommendation for cold starts:
For vehicles with long hydraulic pipes, e.g. buses, an increased flow pressure is required for cold starts under 0°C ambient temperature. In order not to damage the pump through too great a pressure, the engine and with it the pump should be run for a few minutes without any movement of the steering wheel. This brings heated oil into circulation and the flow pressure will then normalize.

The following sections show the intervals for inspections of ZF power steering systems in kilometres per hour and in working hours. The figures in km/h must be applied for road vehicles, the figures in working hours for off–road vehicles. With vehicles having neither a tachometer nor a working hour meter, a fuel flow volume corresponding to the intervals should be taken as a guideline (Section VIII, Instructions for inspection).
For single–circuit hydraulic steering systems, the sections referring to the mobility–dependent pump are omitted.

1. Inspection

The general customer service for the respective vehicle encompasses checking all screwed connections and pipes of the power steering system, pumps (depends on engine and mobility), valves and working cylinders for tightness. A thin film of oil can be applied to the piston rods of the working cylinder, but no drops should be allowed to form.

If the steering system is installed subsequently, the installing workshop should carry out this inspection after the first 1000 kilometres or 25 hours of operation.

2. Oil grades

A suitable hydraulic fluid is required for the perfect functioning of the steering system and the pump. The hydraulic fluid also lubricates the steering gear and the pump; only one oil is therefore required for the whole system.

ATF oils, with a viscosity of approx. 26 mm²/s at 50°C, setting point under –35°C and low frothing inclination, are suitable for filling. Oils with higher viscosity can lead to the ventilating pressure in the suction being too great, producing noises in the pump. For permissible oil grades see list of lubricants TE–ML 09.

3. Oil volume

The hydraulic power steering is supplied from the factory without oil. The volume of oil required for the steering gear, without pipes, oil tank and pump, for the individual steering sizes is:

Type 8033: 0.5 dm^3	Type 8056: 0.8 dm^3	Type 8090: 0.6 dm^3
Type 8036/37: 0.7 dm^3	Type 8058: 1.0 dm^3	Type 8095: 1.5 dm^3
Type 8038: 0.9 dm^3	Type 8060: 1.2 dm^3	Type 8096: 1.7 dm^3
Type 8042: 1.5 dm^3	Type 8062: 1.4 dm^3	Type 8097: 1.9 dm^3
Type 8043/44: 1.4 dm^3	Type 8065: 1.7 dm^3	Type 8098: 2.4 dm^3
Type 8045: 1.9 dm^3	Type 8066: 1.5 dm^3	
Type 8046: 1.6 dm^3	Type 8070/72: 2.6 dm^3	

4. Oil change

Attention
An oil change is only recommended if the steering gear or pump or both have to be repaired or replaced. When doing so, the filters in the oil tanks should also be replaced and the pipes cleaned. An oil change is also required if other oils are used instead of the prescribed ATF oils (see Para. 2, Oil grades), e.g. engine oils or hydraulic fluids.

Before removing the cover of the oil tank, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

Do not reuse oil that has been drained. Avoid mixing oils.

The oil can be drained as follows:

ZF Servocom:
Jack up steering axle as instructed by the vehicle manufacturer. Unscrew pressure and return pipes. If necessary, remove plug screws (55) from cylinder cover or housing. Then start engine briefly, no more than 10 seconds, until oil is drained from pump and tank. To check, switch engine off and turn steering once more from lock to lock until no more oil runs out. There should be a sizeable residual volume of oil in the steering system. Depending on the degree of contamination of the oil, e.g. scuff from the abrasion of internal parts of the pump, the steering system may need to be evacuated completely. The steering must then be dismounted and opened by a ZF service agency.

ZF recirculating ball power steering with oil drain screw:
Jack up steering axle as instructed by vehicle manufacturer. Unscrew oil drain screw on underside of housing.

ZF recirculating ball power steering without oil drain screw:
Undo the plug screw located on the side of the housing cover. Turn steering until the piston is pushed up to the stop. Then start engine briefly, no more than 10 seconds, until oil is drained from pump and tank.
It is possible that a rather large volume of oil will remain in the steering system. If necessary, we recommend that an oil change is followed by another rinse, i.e. that a second oil change is carried out.

To check, switch engine off and turn steering once more from lock to lock until no more oil runs out. Screw in oil drain screw or plug screw M 12x1.5 and tighten with 40 to 45 Nm.

Avoid mixing oils.

5. Filter change

The filter cartridges in single or multi–chamber oil tanks should be replaced at the same time as the inspection [2].

Attention
Before removing the cover of the oil tank, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

When removing the used filter cartridges, ensure by closing the lower hole that dirty oil does not run from the filter cartridges back into the oil tank or into the oil circuit. Lubricate filter holders before use. If oil tanks are plastic, remove suction and return pipe. Disassemble oil tank, evacuate, clean and use new filter cartridges.

[2] Slight deviations are permissible if desired by the vehicle manufacturer in order to be able to record the intervals in the vehicle log.

6. Oil filling and ventilation

6.1 Oil filling

Attention:
When the steering system is being filled with hydraulic fluid, there is a danger that particles of dirt will get into the steering oil circuit. In order to avoid malfunctions caused by foreign bodies in the system, the utmost cleanliness must be ensured both on first filling and on refilling.

The steering system and the pump are filled through the filler necks on single and multi–chamber oil tanks. On first filling and oil changes, it is expedient to remove the tank cover (possible for sheet metal oil tanks) and fill hydraulic fluid up to the neck of the tank.

Start the engine at low speed and allow to work at idle speed (for vehicles with mobility–dependent emergency steering pump: drive axle with gear engaged for mobility–dependent drive axle jacked up) in order to fill the complete hydraulic system with oil. During this process, the oil level in the tank falls rapidly. The oil tank must therefore be constantly refilled to avoid the intake of air. We recommend that one mechanic runs the engine while a second pours in as much oil as is drained by the pump.

At a higher engine speed or strong suction flow, smallish air bubbles would be sucked into the pump again and be broken down into tiny bubbles by the working of the pump; this can lead to frothing and prolong the ventilation process accordingly.

When the steering system must be filled for the first time or after repairs, oil must be poured in before the suction pipe is fastened in the pump connection in order to prevent dry running in the start–up phase. Ensure particularly careful ventilation of the suction pipe. In cases where free suction of the radial piston pump is hampered, it is recommended that the suction pipe is first filled with oil.

6.2 Ventilation

When the steering system has been filled so that the oil level no longer falls below the upper marking on the dipstick, run the engine for some time (2–3 minutes) at low speed (for vehicles with mobility–dependent emergency steering pump: drive axle with gear engaged for mobility–dependent drive axle jacked up). The majority of the air will escape from the cylinder compartments. The oil level should be observed during this process. If it falls still further, top up with oil immediately. To accelerate the ventilation process, it is recommended that the steering wheel is turned several times from lock to lock. At the limit positions, do not pull on the steering wheel any more than is necessary to turn the steering. Top up with oil if necessary until the oil remains constant at the upper mark of the dipstick and no air bubbles rise in the oil tank when the steering wheel is turned.

In vehicles with an additional working cylinder, the pipe connections must point up so that the air in the cylinders and pipes can escape. Undo or remove working cylinder if necessary.

For steering versions with automatic ventilation:

Steering versions with automatic ventilation no longer have vent screws. These steering systems automatically force out the air remaining in the housing after the above ventilation process. Automatic bleeder valves only operate in the flow pressure area, which is why unnecessary pressure build–up is to be avoided.

For steering versions with vent screw:

Note:
Do not turn the steering wheel during the ventilation process and run the engine at low speed. Remove plug cap on vent screw. Then open vent screw 1/2–1 revolutions so that air remaining in this part of the housing can escape. As soon as it is only oil that runs out of the hole of the vent screw, close this again and top up with oil. Then turn steering wheel several times by jerks from lock to lock and repeat ventilation process. Top up with oil. Tighten vent screw with 5 Nm. Replace plug cap.

With Servocom steering systems without automatic ventilation (horizontal fitting position of steering shaft bottom), the upper steering limiting screw (20 or 128) provides the ventilation. The lock nut must be loosened for this purpose. The hydraulic steering limiter must be inspected after the ventilation process.

If the above instructions were observed, the oil level in the oil tank must not rise more than 1 to 2 cm when the engine is stopped, depending on the size of the steering system. The residual air still remaining in the housing is not noticeable when driving. It is absorbed and expelled by the oil during driving operation.

Turn engine off and lower steering axle or drive axle.

7. Checking the oil level

The oil level should be checked at intervals of 5000–6000 kilometres or 100–120 hours of operation. Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

Attention:
Too low an oil level can lead to malfunctions causing partial or complete failure of the steering system. If oil has been lost, it is essential that the point of leakage is located and the damage repaired. Repairs to the steering gear should only be carried out in our ZF service agencies.
For vehicles with ZF Servocom RAS (rear axle steering system):
If the oil level is above the upper mark, there may be a leak in the master cylinder of the ZF Servocom RAS. This leads to oil being forced from the ZF Servocom RAS into the front axle steering system.

7.1 Checking oil level with engine stationary

To ensure that no air is sucked in when the engine is started, determine first whether there is any loss of oil with the engine stationary (vehicles for mobility–dependent emergency steering pump: drive axle for mobility–dependent pump not driven). The tank must be topped up with enough oil so that the oil level is approx. 1 to 2 cm above the upper mark of the dipstick.

7.2 Checking oil level with engine running

With the engine running (vehicles with mobility–dependent emergency steering pump: gear engaged and drive axle for the mobility–dependent pump jacked up as instructed by the vehicle manufacturer), the oil level falls a little because the oil requires a pressure of 2 to 4 bar as a result of the flow resistances in order to flow through the steering gear.

Now enough oil is poured in for the oil level to be constantly at the upper mark. The engine can then be stopped again. The oil level must rise max. 1 to 2 cm. If this is exceeded, it shows that air is still trapped in the oil.

Irksome noises may be produced in the steering system if:

1. A filter cartridge is contaminated, replace with new one.
2. Screwed connections on suction side are not sufficiently tightened, so that air is sucked in. Tighten connections, apply varnish paint if necessary.
3. There is too little oil in the system. Top up with oil.

IV. Adjustments to the steering system installed in the vehicle, types 8033–46 and 8056–70

Note:
The measuring and setting tools used must be inspected regularly for accuracy.

1. Eliminating steering free play in straight–ahead driving (setting pressure point)

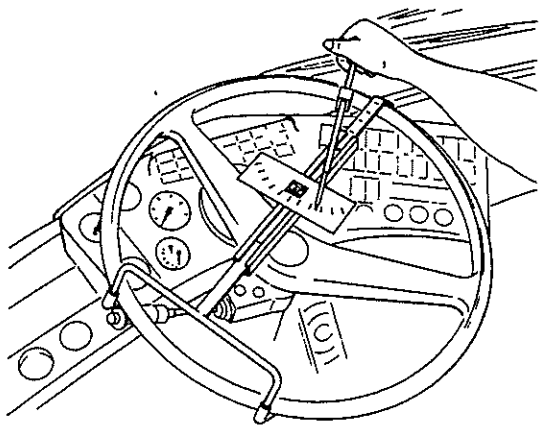
   a) Jack up steering axle.

   b) Turn steering into centre position (roughly found by halving the total number of revolutions of the steering wheel) and remove eccentric rod of steering arm (Section IX).

   c) Undo sealing nut (50 or 27) on housing cover.

   d) Turn steering into limit position and measure the moment of friction required to turn the steering out of straight–ahead driving (approx. 1/2 revolution before end lock). To turn the steering, the tool [6] should be used and this is placed and clamped to the rim of the steering wheel ***(Illus. 21)***.

   e) Then measure moment of friction of steering in pressure point area (centre position). To do this, make 1/2 revolution on tool [6] to left and to right across straight–ahead driving and tighten the adjusting screw (31 or 62) until an increase in moment of friction of 40–60 Ncm is measured over the value measured under Para. d).



Illus. 21

   f) Tighten sealing nut (50 or 27) with a torque of 90 Nm (for lock nut without seal, 70 Nm), while holding the adjusting screw tight. Check set torque again.

It will not improve steering property and the contact ratio in any way if the moment of friction in the straight–ahead driving area is set to be greater than 60 Ncm. Instead, it will produce too great a pressure on the adjacent parts and thereby unnecessary abrasion.

Mount and secure eccentric rod (adhere to tightening torques of vehicle manufacturer).

2. For setting of steering limiter, see Section II.

Free play in the hydraulic power steering with pump stationary and operating

In normal driving, i.e. when the oil pump discharges pressure oil, the torsion bar is twisted and the steering valve offset when the steering wheel is turned or there is a bump. This causes the hydraulic booster to engage. Only a very slight turn of the steering wheel or the sector shaft is required for this control process, so that a perceptible assistance becomes effective.

It is different if the power steering is actuated while the pump is stationary, e.g. when towing. With greater steering forces the whole valve lift of the control valve up to the stop must be overcome before the rotary movement of the steering wheel is transmitted to the sector shaft. There is then a perceptible free play when steering without hydraulic assistance on the steering wheel.

V. Instructions for eliminating external leaks

Attention:
To guarantee safe functioning of the steering system, ensure the utmost cleanliness when carrying out installation. Under no circumstances must force be used when assembling. The resulting damage could lead to the partial or complete failure of the steering function.
The measuring and adjusting tools used for repair must be subjected to a regular inspection for accuracy.

Note:
The numbers in brackets, e.g. (22), refer to the numbers in exploded views and the list of replacement parts.

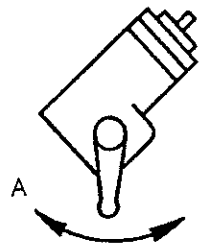
Grades of oil used: Spectron FO 20 from DEA or equivalent calcium complex grease of consistency class 2.

1. Replacing the shaft seal on the steering arm, type 8033–46

1.1 Mark position of universal joint, arrow of protecting cap and steering arm stump to each other and/or check agreement of marking stroke on steering arm stump with clamping slot of universal joint. Remove lower fastening screw on universal joint and pull universal joint from serration of lower steering column. Remove protecting cap (70).

1.1.1 For steering version with intermediate cover

Attention:
When carrying out the following operation, ensure that the worm is not screwed out of the thread of the piston, as there is otherwise the possibility that balls from the planetary thread will fall into the piston hole, which may lead to the steering being locked. This is best prevented if the steering wheel is turned to the full lock at which the piston is in the upper position or the steering arm swings forwards in direction "A" ***(Illus. 22)***. At the same time, the intermediate cover remains on the housing.



Illus. 22

a) Unscrew fastening screws (132). Remove cover (128). Press out shaft seal (129).

b) Use tool [8] to press new shaft seal (129) into cover (128) with sealing lip pointing into housing. Fill cavity between sealing lip and dust lip with grease (see note).

c) Place tool [9] on lower steering arm and fit cover (128). Screw in fastening screws (132) and tighten.

Tightening torques:	M 10:	62 Nm
	M 12x1.5:	115 Nm
	M 14x1.5:	190 Nm

1.2 For steering versions with ring nut in cover or short radius

a) Disconnect retaining ring (130). Remove shaft seal (129) using a suitable hook. Do not damage seal seat while doing so.

b) Place tool [9] on steering arm. Use tool [8] to press new shaft seal (129) into cover (128) with sealing lip pointing into housing. Only insert seal far enough to just guarantee that the retaining ring (130) is in the correct groove and that the vent groove is not covered.

Fill cavity between sealing and dust lip with grease (see note).

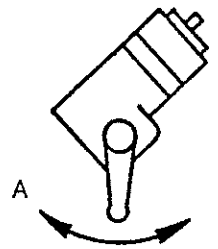
1.2 Apply grease to shaft seal (see note) and fit protecting cap (70). Protecting caps of new design on the housing must be pretensioned. Push universal joint on serration in such a way that the slot of the lower yoke aligns with the marking on the steering arm.

Put hexagon screw through hole of yoke; ensure that hole and free rotation of steering arm stump are congruent. Tighten nut.

Tightening torques:	M 8:	24 Nm
	M 10 x 1.25:	48 Nm

2. Replacing the shaft seal on the steering arm, type 8056–70

Attention:
When carrying out the following operation, ensure that the worm is not screwed out of the thread of the piston, as there is otherwise the possibility that balls from the planetary thread will fall into the piston hole, which may lead to the steering being locked. This is best prevented if the steering wheel is turned to the full lock at which the piston is in the upper position or the steering arm swings forwards in direction "A" ***(Illus. 23)***. At the same time, the intermediate cover remains on the housing.



Illus. 23

a) Mark position of universal joint, arrow of protecting cap and steering arm stump to each other and/or check agreement of marking stroke on steering arm stump with clamping slot of universal joint. Remove lower fastening screw on universal joint and pull universal joint from serration of lower steering arm. Remove protecting cap (160).

b) Disconnect pressure and return line from steering system.

c) Unscrew fastening screws (95 and 134). Remove valve housing. Press out shaft seal (131) from outside in.

d) Use tool [12] to press new shaft seal (131) into valve housing with sealing lip pointing into housing. Fill cavity between sealing lip and dust lip with grease (see note).

e) Place tool [13] on lower steering arm and then fit valve housing carefully. Screw in fastening screws (95 and 134).

Tightening torques:	M 8 x 1- 8.8:	25 Nm
	M 8 x 1- 10.9:	35 Nm
	M 12 x 1.5:	115 Nm
	M 14 x 1.5:	206 Nm

f) Apply grease to shaft seal (see note) and fit protecting cap (160). Push universal joint onto serration in such a way that the slot of the lower yoke aligns with the marking on the steering column.

g) Put hexagon screw through hole of yoke; ensure that hole and free rotation of steering arm stump are congruent. Tighten nut.

Tightening torques:	M 8:	24 Nm
	M10 x1.25:	48 Nm

3. Replacing the shaft ring on the drive bevel gear for versions with angle gear, type 8090–98 and 8056–70

a) Remove lower fastening screw on universal joint. Pull universal joint from serration of bevel gear. Remove protecting cap (314).

b) Undo slotted nut (313) and remove setting screw (312) from housing (301).

c) Press shaft seals (310 and 310.1) from setting screw. Pull o–ring (308) from housing slot.

Attention:
The bevel gear should only be extracted from the housing if absolutely necessary, e.g. for polishing the seal surface, as otherwise the meshing, which must have no free play when the steering gear is in straight–ahead driving position, will no longer be true. In this case, first turn the steering into straight–ahead driving position and then bring the notch on the steering arm congruent with the housing marking.

d) Fit o–ring (308) into radial slot of the housing, behind the tapped hole. Press the two shaft rings (310 and 310.1) into the setting screw (312) (the dust lips seal first) with the sealing lips pointing into the housing. Fill the cavities between the sealing lips with grease (see note).

e) To protect the sealing lips of the shaft seals, place tool [13] on the serration of the bevel gear. Push setting screw (312) on and screw in. Only tighten setting screw until the bevel gear is free of axial play. (The moment of friction of the bearing setting when the angle gear is dismantled must be 40 to 70 Ncm). Fit slotted nut (313) and tighten with 50 Nm, while holding setting screw firmly. Apply grease to shaft seal (see note), slide on protecting cap (314 and 70 or 160).

f) Push universal joint on serration in such a way that the slot in the lower yoke and the marking notch on the bevel gear agree.

g) Put hexagon screw through hole of yoke. Tighten nut.
Tightening torques: M 8: 24 Nm and M 10x1.25: 48 Nm

4. Replacing the shaft seal on the steering shaft, type 8033–46 and 8056–70

Note:
The following operation only applies to steering versions in which the steering shaft is sealed by means of shaft seals (4 or 6) instead of oval seals together with back–up rings, e.g. types 8043 and 8066. If the oval seals are not tight, the steering system must be disassembled. This should only be carried out by ZF service agencies.

a) Remove mounting of steering arm and remove steering arm using tool [7].

Attention:
Under no circumstances should the steering arm be removed by heating or driving in a wedge between the neck of the housing and the steering arm or by hammering, as this causes damage within the steering gear and material changes to the steering arm.

b) Disconnect retaining ring (7 or 3) on housing neck.

c) Remove shaft seal (6 or 4) from the housing neck using a suitable screwdriver or hook.

d) Plush tool [10] or [13] onto steering shaft. Push shaft seal with sealing lip to housing and with grease (see note) between sealing lip and dust lip over the sleeve and press into housing neck using tool [11] or [15].

e) Replace retaining ring (3 or 7). Push dust seal (1.1) with grease (see note) between dust seal and housing up to location on the sector shaft.

f) Push steering arm onto steering shaft; the marks on the steering arm and the shaft must agree. Tighten and secure hexagon nut with torques given in Section X.

VI. Removing and installing pressure relief valve and replenishing valve

1. **Pressure relief valve** – ZF Servocom and ZF recirculating ball power steering, type 8033–46

a) Unscrew valve core (22 or 23) from housing. The valve core cannot be disassembled. In the event of wear or pressure deviation, the complete valve must be replaced.

b) Fit greased o–ring (23 or 22) into slot of valve core (22 or 23). Screw in valve core.

c) Tightening torque: 30 Nm.

2. **Replenishing valve** – ZF Servocom, type 8090–98

a) Unscrew screw (30) and valve core (32).

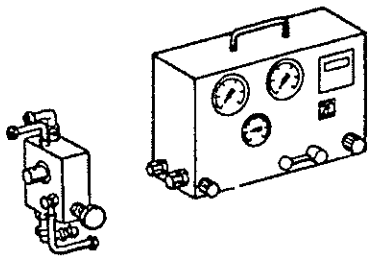
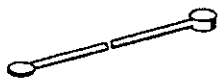
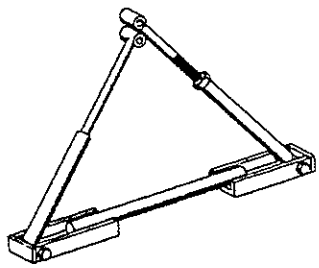
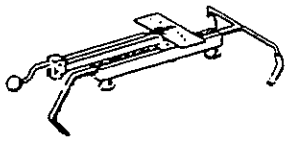
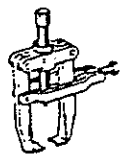
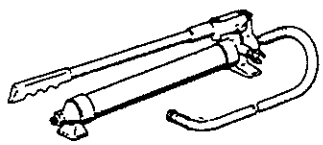
b) Insert valve core (32) into housing hole. Screw in screw (30) with fitted and greased o–ring (21).

c) Tightening torque: 30 Nm.

Attention:
With the exception of the work given under Sections IV, V and VI, no other repairs necessitating disassembly of the power steering should be carried out. Repairs going beyond the work described above should be carried out by a ZF service agency.

VII. Special tools

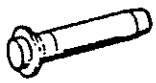
a) Tools for inspection

		Tool number
Tool [1] a) Servotest 550 hydraulic steering tester b) Sep. flow control valve 2 dm^3/min - Servocom only		7418 798 550 7418 798 539
Tool [2] Dial with pointer for checking free play on steering wheel		7418 798 452
Tool [3] Thrust piece for limiting wheel turn (use special tool prescribed by vehicle manufacturer)		7418 798 556
Tool [4] 1 pair spreaders (use special tool prescribed by vehicle manufacturer)		7418 798 653
Tool [5] Locking device for steering arm (use special tool prescribed by vehicle manufacturer)		7418 798 652
Tool [6] Torque meter for setting pressure point		7418 798 703
Tool [7] Extracting device for steering arm		7418 798 202
a) Extracting device		
b) Hydr. extracting device consisting of: Hand pump		7016 798 201
Cylinder		0646 121 048
Bell for steering shaft diameters up to 45 mm		418 798 214
for steering shaft diameters from 55 mm, useful width 102 mm		7418 798 213
for steering shaft diameters from 55 mm, useful width 120 mm		7418 798 216

b) Tools for repair, type 8033–46

	8033	8036	8037	8038	8042	8043 8044	8045	8046
Tool [8] Inserting sleeve or mandrel for shaft seal (129) – steering arm a) for version with intermediate cover (122) 		8052 798 056		7418 798 051			7418 798 051	
b) for version with ring nut in cover (128) or short radius 	8033 798 001		8037 798 002	7404 798 001				
Tool [9] Sleeve for protecting shaft seal (129) on lower steering arm 	7832 798 001	8052 798 003	7359 798 001	7418 798 006				
Tool [10] Guide sleeve for protecting shaft seal (6) on sector shaft 		7409 798 001		7425 798 002	8065 798 001		7438 798 002	
Tool [11] Guide sleeve or inserting sleeve for shaft seal (6) in housing neck 		7419 798 003		7425 798 002	8065 798 002		7438 798 003	

c) Tools for repair, type 8056–70

	8056	8058	8060 8062	8065	8066	8070
Tool [12] Mandrel for shaft seal (131) in valve housing 	8052 798 051		7418 798 051			
Tool [13] Guide sleeve for protecting shaft seal (131) on lower steering arm 	8052 798 003		7418 798 006			
Tool [14] Guide sleeve for protecting shaft seal (4) on sector shaft 	8056 798 001	7409 798 001	7425 798 002	8065 798 001		7438 798 002
Tool [15] Inserting sleeve for shaft seal (4) in housing neck 	8056 798 002	7419 798 003	7425 798 003	8065 798 002		7438 798 003

VIII. Instructions for inspection

Vehicles with ZF hydraulic power steering should be taken to the workshops of the vehicle manufacturer or the ZF service agencies for inspection of the ZF steering systems and ZF oil pumps according to the following mileages and operating hours.

The inspection intervals given below depend on the type of use of the vehicle. For vehicles fitted with neither a tachometer nor an operating hours counter, a fuel flow volume corresponding to the intervals should be used as a guideline.

❑ **For ZF recirculating ball power steering systems, types 8033–8046, types 8056–8070 and ZF Servocom steering systems produced up to 12/93**

Type of use	1st inspection Inspection in vehicle	2nd inspection Inspection in vehicle	3rd inspection
- Long–distance vehicles	100 000 km 60 000 miles	200 000 km 120 000 miles	300 000 km 180 000 miles
- Vehicles in highway and short–distance use	100 000 km 60 000 miles	175 000 km 105 000 miles	250 000 km 150 000 miles
- Construction vehicles and off–road vehicles	80 000 km 50 000 miles 2 500 op. hrs.	150 000 km 90 000 miles 4 500 op. hrs.	200 000 km 120 000 miles 6 000 op. hrs.

To increase road safety, we recommend that the steering system and pump are disassembled in the 3rd inspection, the mechanical steering parts examined (visual examination of all parts and check for cracks on parts under stress) and new sealing parts are fitted. This work should be carried out by a ZF service agency.

❑ **For ZF Servocom steering systems produced from 1/94**

Type of use	1st inspection Inspection in vehicle	Additional inspection Inspection in vehicle
- Construction vehicles - Vehicles for short–distance use - Vehicles with high load population	200 000 km 6 000 op. hrs or after no more than 5 years	every 200 000 km 6 000 op. hrs or after no more than 5 years
- Long–distance vehicles - Buses	500 000 km	after every additional 250 000 km

Carrying out the 1st and 2nd inspection

Note:

a) In order to be able to form an idea of the condition of the vehicle and the power steering before carrying out the following inspection, and to compare the performance of the power steering before and after inspection, we recommend a test drive. This is particularly recommended if the driver has a poor opinion of the steering system. Before going on a test drive, check the oil level and ventilation of the steering system.

b) The measuring and adjusting tools used must be subjected to regular inspection.

1. Checking the mechanical functioning of the steering

Attention:
Do not turn steering systems with automatically adjustable hydraulic steering limiter into limit positions when the steering linkage has been removed (see Section II, Para. 1.5).

1.1 Checking seat of the fastening screws

Tighten screws on steering and steering mounting with the torque prescribed by the vehicle manufacturer. Check sheet metal and splint mounting for perfect performance. By alternately turning and straightening the steering wheel while the vehicle is stationary, check whether the steering arm still has a firm seat on the serration of the sector shaft.

1.2 Checking straight–ahead driving position of steering and vehicle

Jack up steering axle as instructed by vehicle manufacturer (if the vehicle does not have a rigid steering axle, the wheels should be on rotary tables). Bring steering into centre position by halving the total number of steering wheel revolutions. Then turn further until markings on steering shaft and housing agree. The wheels steered should be in straight–ahead driving position (this can be checked roughly by placing a measuring strip on both front wheels and back wheels and noting toe–in). Correction is effected by screwing ball joint on eccentric rod in or out.

Attention:
If the steering linkage must be corrected longitudinally, the reason for this may be a previous accident–type incident. It is recommended therefore that the serration on the sector shaft (30) is examined for torsion (remove steering arm to do this), the steering shaft for distorted installation and all other transmission parts for bending or cracks and that the free play is measured according to Para. 7.7. Deformed parts must not be bent straight but should be replaced.

For versions with automatically adjustable hydraulic steering limiter ZF Servocom:
If necessary, install new valve sleeve assemblies (20 or 128) and reset steering limiter – see Section II Para. 1.5.

1.3 Checking free play between piston and sector shaft in centre position

a) Turn steering into centre position (see 1.2) and remove eccentric rod from steering arm.

b) Measure moment of friction when turning across the pressure point area. It should be greater by the following values than outside the pressure point:

Type 8090: 20 - 60 Ncm
Type 8095: 20 - 80 Ncm
Type 8097/8098: 20 - 100 Ncm

Type 8033–46: 40 – 60 Ncm
Type 8056–70: 40 – 60 Ncm

To set pressure point (only types 8033–46 and 8056–70), see Section IV. Adjustment of pressure point with ZF Servocom is only possible when dismounted (ZF service agencies).

1.4 Checking steering lock

Connect eccentric rod temporarily. Turn steering to the left up to lock. Disconnect eccentric rod and turn steering wheel further to ascertain whether there is still steering reserve. Repeat measurement to right. There must be steering reserve on both sides. If this is not the case, the wheel lock screws must be reset. Connect eccentric rod again.

Note:
When the steering linkage has been removed, steering systems with automatically adjustable hydraulic steering limiter (ZF Servocom) may only be turned into limit positions if there is to be a subsequent resetting with new valve sleeve assemblies (128); if necessary, remove valve sleeves and fit plugs for this inspection.

1.5 Checking free play of steering shaft support in steering column

Check whether there is free play by making lateral movements (shaking) on the steering wheel. If there is free play, replace bearing bush.

1.6 Checking circumferential backlash or sluggishness in universal joint or in flexible disk between upper steering shaft and steering gear

If there is free play (produces audible rattling on shaking) or sluggishness, fit new part.

1.7 Checking steering shaft and jacket tube for maximum permissible bend

Jack up steering axle as instructed by vehicle manufacturer. Remove steering wheel and self–aligning bearing ring or ball bearing bush from the jacket tube. Check the permissible bend of steering shaft and jacket tube in accordance with Section X.

2. Checking for external tightness

a) Start engine.

b) Check whether all screwed connections and lines of steering system and seals on steering and pumps are tight. Tighten screwed connections and replace seals if necessary. When fitting new seals, we recommend that you use our special tools.

c) Check all hoses and lines for possible abrasion points and brittle cracks. Replace defective parts.

Attention:
For hose lines and externally visible damage such as cracks, fit only pressure–tested replacement parts recommended by the manufacturer. Note replacement part numbers of vehicle manufacturer.

d) Stop engine.

3. Checking V–belt tension

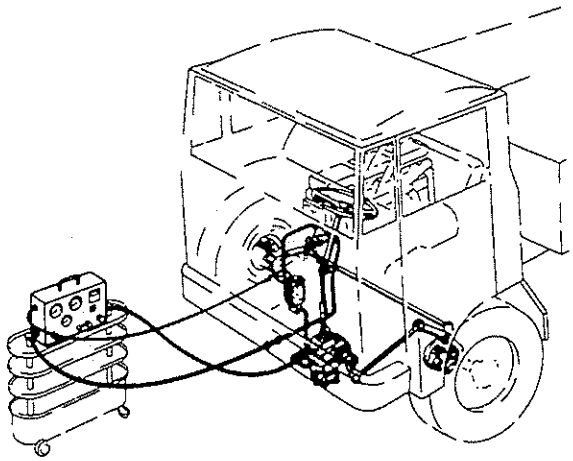
Check tension of V–belts using the usual thumb tests (adhere to instructions of vehicle manufacturer). The V–belts must not overrun even under maximum pressure. Replace defective V–belts.

4. Fitting hydraulic steering tester

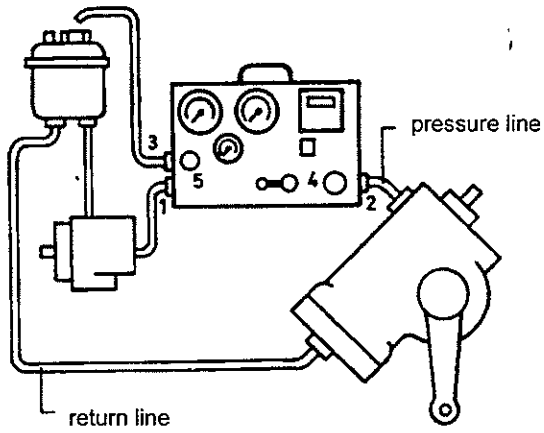
Fit Servotest 550 hydraulic steering tester in the pressure line between oil pump and ZF power steering (see ***Illus. 24*** and ***25***) in such a way that the display instruments can be easily observed from the driver's seat. Connect pressure line from pump with connection "input 1" of tester and connection "output 2" with line to the steering (see separate operating instructions for Servotest 550). Steering systems which have a pressure relief valve positioned according to Section 7 Para. 2b) must be connected to the oil tank from connection "tank 3" of the tester.

It is enough to insert the hose end into the opening of the removed tank cover. See ***Illus. 25*** for diagram of connections. Note oil level and top up if necessary. Ventilate steering system.

Illus. 24
Hydraulic connection diagram for hydraulic steering tester using ZF Servocom steering system as example



Illus. 25
Position of hydraulic steering tester valves after connection (idle position):
pressure relief valve 120 bar,
throttle valve closed, shutoff valve open.



5. Oil filling
See Section III (maintenance and oils).

6. Ventilation
See Section III (maintenance and oils).

7. Checking hydraulic functioning of steering and pump

Note:
To carry out the following pressure and overflow oil checks, 2 types of steering must be differentiated.

a) Steering systems in which **the pressure relief valve** is located **in the pump or pressure line**. This means that the pressure is relieved before the installed tester. In these steering systems, the maximum pressure, e.g. 100 bar, is indicated on the rating plate of the pump or pressure relief valve.

b) Steering systems in which the **pressure relief valve** is installed **in the steering system or separately in the pressure line between tester and steering**. The valve can thus no longer control the oil pressure if the pressure lines are blocked by the installed shutoff valve of the test device. In these steering systems, the maximum pressure is indicated on the rating plate of the steering or pressure relief valve.

7.1 Checking ZF pump for pressure

Read the maximum pressure from the rating plate of the steering or the pump or the separate pressure relief valve. Run engine until warm. Oil temperature 50°C.

a) For steering systems with pressure relief **before** tester:

With the engine at idle speed, close shutoff valve of tester. Read pressure from manometer.

Attention:
Only operate maximum pressure for a short time, no more than 5 seconds, as otherwise the internal parts of the pump will be too hot, leading to premature wear. Bring shutoff valve into starting position again. The permissible deviation from nominal pressure must be no more than ± 10%.

If the difference is greater, the functioning of the pressure relief and flow control valve must be checked and the valve adjusted if necessary.

Checking the valve:
Remove pressure relief and flow control valve from ZF oil pump. Check valve piston and hole in valve housing for visible wear. The holes in the valve piston must not be clogged. The piston must be able to be moved slightly and must not stick. If necessary, a new valve must be fitted.

If the maximum pressure of the pump is still too low after this check, the internal parts of the pump must be examined for wear. In this case we recommend that the pump is exchanged.

b) For steering systems with pressure relief **behind** tester:

Attention:
If the tester has been installed as described in b), ensure that the engine is only run at idle speed for the complete duration of the pressure testing. An increase in engine speed would result in an immediate, jerky rise in the oil pressure. In this case there is a danger that the pressure line will become defective or the pump will seize up.

With the engine at idle speed and while observing the manometer, close the shutoff valve of the tester slowly until the maximum pressure has been reached. Do not close valve any more (only operate maximum pressure for a short time, no more than 5 seconds, as otherwise the internal parts of the pump will be too hot, leading to premature wear). Bring shutoff valve into starting position again. If the measurement does not show nominal pressure, the functioning of the flow control valve must be checked and the valve adjusted if necessary.

Checking the valve:
Remove flow control valve from ZF oil pump. Check flow control valve piston and hole in valve housing for visible wear. The holes in the valve piston must not be clogged. The piston must be able to be moved slightly and must not stick. If necessary, a new valve must be fitted.

If the maximum pressure of the pump is still too low after this check, the internal parts of the pump must be examined for wear. In this case we recommend that the pump is exchanged.

7.2 Checking ZF oil pump for flow rate using Servotest 550 hydraulic steering tester

Note:
For setpoint values for flow rate, test pressure and test speed, see table. For descriptions and operation of hydraulic steering tester, see separate operating instructions for Servotest 550.

a) Checking minimum flow rate

With engine at idle speed, close shutoff valve until test pressure for pump type is reached. Read off flow rate. Note conversion of engine speed to pump speed.

At a pump pressure of 50 bar (120 bar for pump type 8601), the minimum flow rate is:

for pump type	minimum flow rate dm^3/min	speed rpm
7633	6.0	800
7634	6.0	700
7636	6.0	500
7638	6.0	400
7646	6.5	350
7671	2.6	500
7672	4.5	500
7673	6.1	500
7674	7.5	500

for pump type	minimum flow rate dm^3/min	speed rpm
7677	8.5	500
7681	3.1	500
7683	4.5	500
7684	5.9	500
7685	7.0	500
7686	9.4	500
8601	2.0	1000
8605	5.0	350
8607	5.0	350

b) Checking the controlled flow rate

Increase speed until the capacity of the pump remains constant despite a further increase in speed, approx. 1300 rpm. The pump is now in the limiter area. The setpoint value of the capacity can be read from the respective list of replacement parts for the oil pump.

7.3 Checking the hydraulic steering limiter

a) Mechanically adjustable hydraulic steering limiter

Turn steering wheel clockwise as described under Section II, with steering axle under stress (jack up rigid axle or use rotary tables for independent suspension). Once the wheel lock has been reached, a brief (max. 5 seconds) continued turning of the steering wheel will overcome the resetting force of the steering valve until a fixed steering wheel lock is achieved. To reach this a peripheral force on the steering wheel of approx. 100–200 N is required. In this position, read off the oil pressure on the manometer; this should be no greater than indicated under Section II. For setting of the steering limiter, please refer to Section II. Para 1.4.

b) Automatically adjustable hydraulic steering limiter – ZF Servocom

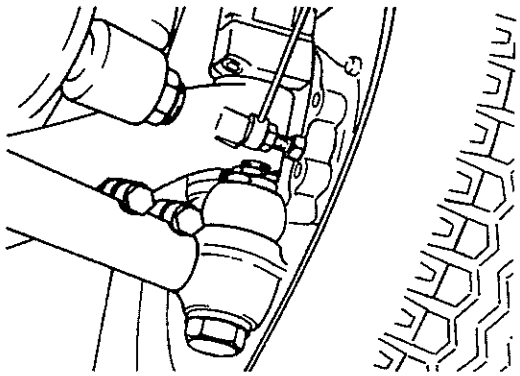
Carry out check as described under a), but with no spacers inserted. If there is no space on the wheel lock parts or the oil pressure does not fall to the value given in Section II Para. 2, fit new sliding valve assemblies (20 or 128) and reset steering limiter according to Section II Para. 1.5.

If the space on the wheel lock parts is too great and the oil pressure falls to the prescribed value, reset steering limiter according to Section II Para. 1.5.

Carry out check in the same way while steering anticlockwise.

7.4 Checking steering system for pressure

Tool [3] or thrust pieces approx. 15 mm thick ***(Illus. 26)*** are inserted between the wheel lock parts in such a way that the steering lock is restricted 1/2 to 3/4 of a steering wheel revolution before reaching full lock. Restriction of the steering lock should therefore be effected using these thrust pieces, but not in the hydraulic power steering through the working piston on the cylinder.



Illus. 26

Attention:
A tool under pressure may be ejected – avoid direct eye contact with the tool. If the tool locks during steering lock, it is essential that there is sufficient clearance between the wheel and the vehicle chassis for this. There is a danger of the hand being squeezed e.g. when the tool is ejected and the wheel subsequently resettles. Depending on the type of axle, use the special thrust piece specified by the vehicle manufacturer.

With engine at idle speed, turn steering wheel to the right until full lock and continue turning right for approx. 5 seconds with a force of 100–200 N on the steering wheel until the self–aligning force of the steering valve is overcome. The oil pressure is read off on the manometer. The same measurement is carried out steering to the left. If, when steering left or right or in both directions, it is discovered that the oil pressure at a steering force of 100–200 N is below the previously measured oil pressure of the pump, the steering hydraulics are not functioning properly. The cause of the pressure drop may be:

a) Pressure relief valve in the steering system (or separate) is not working properly.

b) There is too much overflow oil in the steering hydraulics (measure overflow oil flow).

7.5 Checking overflow oil using hydraulic steering tester

Note:
For descriptions and operation of hydraulic steering tester, see separate operating instructions for Servotest 550.

a) For steering systems with pressure relief before tester:

Keep 15 mm thick thrust piece between the wheel lock parts. With engine at idle speed, turn steering to full lock and pull on steering wheel with approx. 100–200 N (max. 5 seconds) so that steering valve is fully closed. Read off overflow oil flow and release steering wheel. Repeat check turning in opposite direction.

Attention:
A tool under pressure may be ejected – avoid direct eye contact with the tool. Depending on the type of axle, use the special thrust piece specified by the vehicle manufacturer.

b) For steering systems with pressure relief **behind** tester:

Close shutoff valve (4) completely and throttle valve (5) until there is back pressure 30 bar lower than the maximum pressure measured under 7.1. Open shutoff valve (4) again.

Keep 15 mm thick thrust piece between the wheel lock parts. With engine at idle speed, turn steering to full lock and pull on steering wheel with approx. 100–200 N (max. 5 seconds) so that steering valve is fully closed. Read off overflow oil flow and release steering wheel. Repeat check turning in opposite direction.

Max. permissible overflow oil values:

Type 8033 to 8037:	2.8 dm^3/min
Type 8038 to 8044:	3.0 dm^3/min
Type 8045 to 8046:	3.2 dm^3/min
Type 8056 to 8058:	2.0 dm^3/min
Type 8060 to 8070:	2.5 dm^3/min
Type 8090:	2.0 dm^3/min
Type 8095 to 8098:	2.5 dm^3/min

For ZF–Servocom type 8090–98:

For Servocom steering systems, the functioning of the high–pressure seals must also be checked while the flow rate is low.
Set hydraulic steering tester to flow rate of 2 dm^3/min. Connect separate flow control valve tool [1b] in series.
Repeat overflow oil check as described under a) or b). The overflow oil should not exceed the previously measured value. If this measurement shows a greater overflow oil value than was the case for measurement under a) or b), the cause may be that seals, especially the seals (117 and 123) in the piston or housing cover, are not in exact contact.

For ZF recirculating ball power steering, type 8033–46 and 8056–70:

Repeat overflow oil measurement with pressure of 20 to 30 bar.

The cause of excess overflow oil may be:

a) Pressure relief or replenishing valve in steering not working properly – replace.

b) Steering limiter valve switches off too early – to set, see Section II.

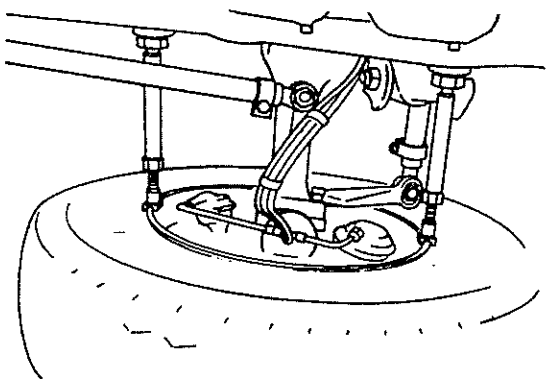
c) Seals in steering are defective – dismantle steering and have repaired by ZF service agency.

7.6 Checking valve restoring force

With the steering arm locked in the centre position, close the control valve by turning the steering wheel, thereby building up the maximum pump pressure. Then slowly release the steering wheel and again set a pump pressure of 10 bar above the flow pressure. The valve must then return to its original position within 1 second, i.e. the oil pressure must fall to at least 0.5 bar above the flow pressure.

7.7 Measuring the free play on the steering wheel with engine running and vehicle stationary in straight–ahead driving position

a) Lock front left wheel (front right wheel in right–hand drive vehicles) into straight–ahead driving position by fitting two expanding devices between wheel rim (front and back) and front spring *(Illus. 27)*.



Illus.27

b) Place dial on steering wheel and attach pointer on dashboard or windscreen ***(Illus. 28)***.

c) With the engine running, begin to turn steering wheel slowly to the left while observing the manometer.

For ZF–Servocom:
higher engine speed, approx. 1000 rpm
oil temperature: 50–60°C

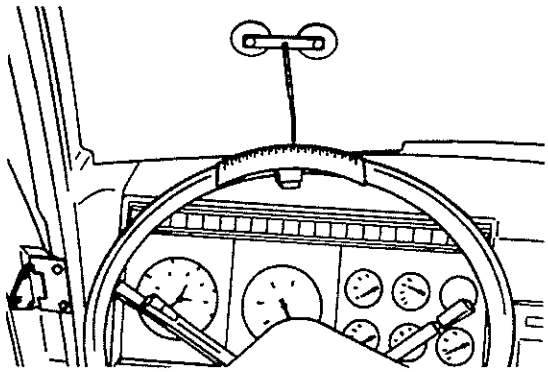
d) When a pressure rise of 1 bar above flow pressure has been reached ***(Illus. 29)***, hold the steering wheel firmly and mark value on scale.
Then turn steering wheel to right, again until a pressure rise of 1 bar has been reached. The total path travelled on the scale is measured.

Max. permissible travel:
Type 8090-98: 40 mm
Type 8033-46: 40 mm
Type 8056-70: 20 mm

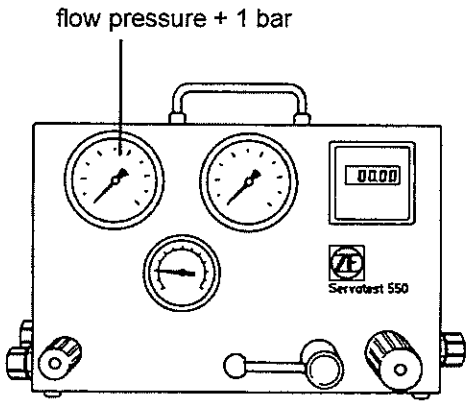
For steering versions with flange–connected or separate angle gear, the free play may be 5 mm greater.

If these conditions are not fulfilled, the measurement must be repeated with the steering arm locked ***(Illus. 30)***, since in the measurement carried out the free play in the ball joints of eccentric and track rods and in the other transmission parts was not eliminated. This check requires a good, play–free condition of the eccentric rod and the ball joint.

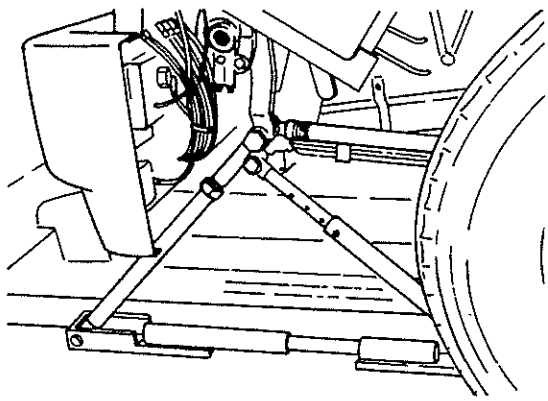
If the travel is greater than indicated even with the steering arm locked, there is mechanical play in the steering gear. This may also be the result of an accident–type impact. The steering gear should then be reconditioned or examined for accident damage by a ZF service agency (check for cracks). Switch off engine. Dismount hydraulic steering tester.



Illus.28



Illus.29



Illus.30

8. Filter change

Attention:
Before removing the oil tank cover, thoroughly clean the tank and its immediate surroundings so that no dirt can get into the hydraulic fluid.

a) Unscrew plug screw from cover of oil tank and remove tank cover.

b) Pull out used cartridge on metal collar. When removing the used filter cartridge, close the lower hole so that dirty oil does not run back into the tank.

   If oil tanks are plastic, remove suction and return pipe. Disassemble oil tank, evacuate, clean and fit new filter cartridge.

c) Grease filter holders and fit new filter cartridge with metal collar pointing up.

d) Fill tank with oil up to neck.

e) Start engine. The oil level will fall rapidly. To avoid the intake of air, top up tank with oil immediately. Then ventilate steering system as described in Section III.

Note:
Illus. 26, ***27*** and ***30*** show universal devices provided by ZF. Depending on the type of vehicle, special devices approved by the vehicle manufacturer may also be required.

9. Test drive

After inspection work, a test drive should be carried out to check the vehicle and steering system for perfect functioning and external tightness.

IX. Removing the steering system from the vehicle

1. Thoroughly clean steering system and the directly surrounding area, especially the line connections.
2. Discharge oil as described in Section III, Para. 4.
3. Disconnect pressure and return lines.
4. Close all oil lines to avoid contamination.
5. Pull off steering arm using tool [7].

Attention:
Under no circumstances should the steering arm be removed by heating or by driving in a wedge between the neck of the housing and the steering arm or by hammering, as this causes damage within the steering gear and material changes to the steering arm.
Do not turn steering systems with automatically adjustable hydraulic steering limiters into limit positions when the steering linkage has been removed – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 or 128).

6. Disconnect universal joint or flexible coupling between steering gear and steering column or separately installed angle gear. Do not hit the steering shaft axially when dismounting the steering wheel.
7. Remove fastening screws on housing and extract steering system.

X. Installing the steering system in the vehicle

Attention:
To guarantee safe functioning of the total steering system, ensure absolute cleanliness when fitting all aggregates belonging to the system and when connecting the lines. To avoid malfunctions due to foreign bodies or dirt in the steering oil circuit, the sealing plugs on the line connections of steering system, oil pump, working cylinder, valves etc. should only be removed when connecting the lines. If possible, do not remove protective sheaths until installation is complete. Connecting lines and screwed connections must be cleaned and deburred carefully.
Do not turn steering systems with automatically adjustable hydraulic steering limiters into limit positions when the steering linkage has been removed – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 and 128).

1. Ensure that contact surfaces of mounting eyes of bearing block and steering system are free of paint and dirt.
2. Place steering gear in bearing block and screw down. Tighten screws with corresponding torque. Depending on the type of vehicle, the steering arm may require prior mounting for reasons of space (see Para. 7).

Attention:
When fastening jacket tube and steering shaft, particularly in the case of a separately installed angle gear with flange–connected jacket tube, it is essential to avoid pretensions which may occur in the steering gear/bearing block due to the retaining connection to the bulkhead or dashboard.
Pretensions can be generated through bending torques, especially in the steering shaft, and depending on size and frequency can in some cases lead to permanent fractures or impair the freedom of the steering gear.

3. To check whether the steering has been correctly installed, proceed as follows:

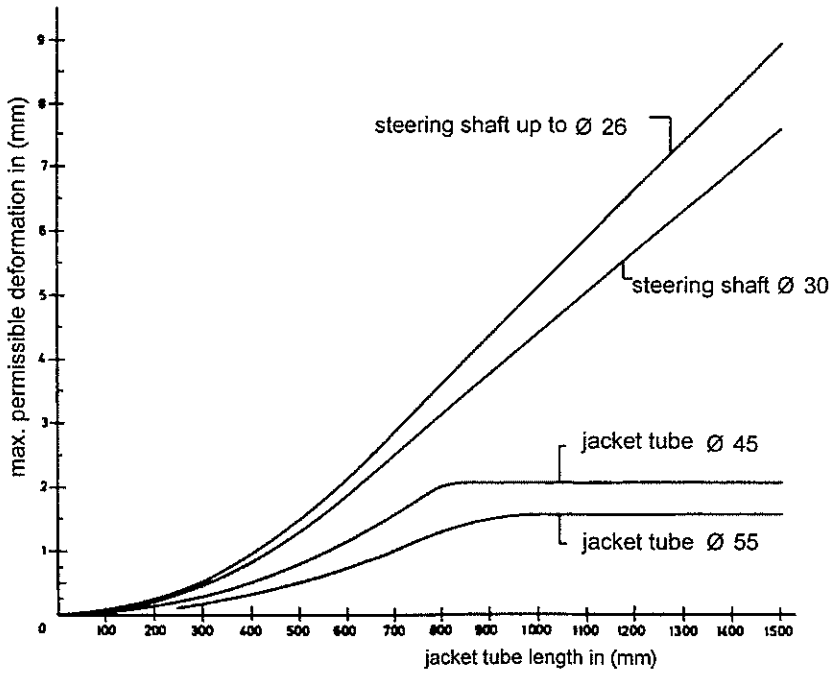
3.1 Check freedom of the steering gear or separately installed angle gear in the assembly with bearing block, steering arm and eccentric rod(s).

3.2 **Checking the permissible deformation of the steering shaft**

a) Raise steering axle in accordance with the instructions of the vehicle manufacturer so that the steering system can be easily turned by hand.

b) Remove steering wheel and dismount ball bearing sleeve or self–aligning bearing from the jacket tube of the separately installed angle gear.

c) By turning the steering shaft at least 360 degrees, establish whether the steering shaft is deformed. The measurement can be carried out using a dial gauge or a depth gauge, although the measurement must always be taken from the same point on the periphery of the jacket tube. The radial run–out measured, divided by 2, gives the deformation of the steering shaft. The maximum permissible deformation depends on the length of the jacket tube and the diameter of the steering shaft (see ***Illus. 31*** and the procedure for determining the length of the jacket tube).



Maximum permissible deformation of jacket tube and steering shaft ***Illus. 31***

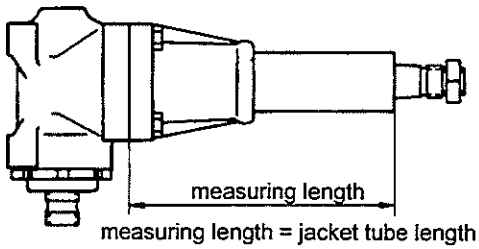
3.3 Checking the permissible deformation of the jacket tube

To do this, the steering shaft must be marked on one point on the periphery. Then turn the steering shaft in stages (at least 4 stages) and after each stage, use the depth gauge to measure the distance always from the external diameter of the jacket tube to the point marked on the steering shaft. Since the same steering shaft side faces the measuring point on the periphery of the jacket tube, the run–out of the steering shaft itself is not measured as well. The difference of the distance, largest measurement to smallest measurement, divided by 2, gives the deformation of the jacket tube. The maximum permissible deformation depends on the length and diameter of the jacket tube (see ***Illus. 31*** and the procedure for determining the length of the jacket tube).

Note:
This check must also be carried out during main inspection of the steering system and for vehicles with previous accident damage in the front area.

3.4 Determining the jacket tube length

Measure the length of the jacket tube including jacket tube flange – parting plane jacket tube flange/ housing ***(Illus. 32)***.



measuring length = jacket tube length

Illus. 32

4. Turn steering system into straight–ahead driving position (determined by halving the total number of steering wheel revolutions). The markings on the steering shaft and jacket tube or valve housing must agree.

5. a) Applies for separately installed angle gear with rigid steering column:

Screw in sliding contact and tighten with 5 Nm. Tightening torques for steering wheel nuts:

with cylindrical serration and cone 1:6:

M 18 x1.5:	35 - 45 Nm
M 22 x1.5:	40 - 50 Nm
M 26 x1.5:	60 - 70 Nm

Attention:
Do not hit the steering shaft axially when mounting and dismounting the steering wheel.

b) Applies for steering systems with separate steering column:

Fit universal joint or flexible coupling between steering column and steering gear. In the straight–ahead driving position, the offset yoke part must be at a right angle to the markings on the steering shaft and jacket tube or valve housing. If two joints are used, the diffraction angle should be the same and the yokes on a plane. If such an installation is impossible, parallelity can be reached by offsetting the yokes to each other on the serration.

With aluminium universal joints, hammer blows on the yokes should be avoided as this can lead to destruction or sluggishness. Connect both by using fit bolts and tightening the nuts. Tightening torques for fit bolts:

M 8: 24 Nm
M 10 x 1.25: 48 Nm

When fitting telescopic shafts, note max. permissible lift range.

6. Bring steered wheels of vehicle into straight–ahead driving position. This is reached when the steered wheels are flush or parallel to the second pair of wheels (use measuring strip on front and rear wheel).

7. Push dust seal (1.1) with Spectron FO 20 grease from DEA or equivalent calcium complex grease of consistency class 2 into spaces on sector shaft. Then place steering arm on serration so that markings on steering arm and sector shaft agree. Provisionally tighten nut securing steering arm and turn steering to the left until full lock. Remove steering arm and continue turning steering wheel to determine if there is still steering reserve available. Repeat measurement turning to the right. Tighten nut securing steering arm with the torque listed below and secure to prescribed place by caulking (peening depth: min. 1.5 mm). Connect and tighten eccentric rod.

For versions with automatically adjustable hydraulic steering limiter:

Remove steering arm and continue turning steering wheel to determine if there is still steering reserve available. Repeat measurement turning to the right.

Screw in sliding sleeve assembly (20 and 128) (tightening torque 15+3 Nm).

Tighten nut securing steering arm with the torque listed below and secure to prescribed place by caulking (peening depth: min. 1.5 mm). Connect and tighten eccentric rod.

Do not turn steering systems with automatically adjustable steering limiter into limit positions when the steering linkage is dismounted – see Section II Para. 1.5. If necessary, fit new sliding sleeve assemblies (20 or 128).

☞ For versions with conical serration:

Thread	Gear	Tightening torques	Exception
M30x1,5	1 3/8"x36	250 Nm +10%	
M30x1,5	1 1/2"x36	300 Nm +10%	
M30x1,5	1 5/8"x36	330 Nm +10%	
M35x1,5		400 Nm +10%	
M42x1,5		500 Nm +10%	
M45x1,5		550 Nm +10%	MAN: 850 Nm+10%

☞ For cylindrical serration or binding screws:

see tightening torques prescribed by vehicle manufacturer

If the vehicle manufacturers specifies other values, these values must be applied.

8. Connect pressure and return line between pump, steering and working cylinder. If lines must be bent, this should be done when cold in order to avoid scaling.

For hose lines with externally visible damage such as cracks, only pressure–tested replacement parts released by the manufacturer should be used. Note replacement part number of vehicle manufacturer.

9. Fill system with hydraulic fluid through oil tank.
   See Section III Para. 6.

10. Startup of steering system

    To avoid any particles of dirt still in the steering system getting into the pressure relief valve on first startup, it is recommended that oil flows through the steering system for some minutes at different engine speeds and without the steering wheel being turned. The steering should then be turned several times in both directions, but not to full lock, at average engine speed (until operating temperature is reached).
    Then ventilate steering system (see Section III).

11. Set hydraulic steering limiter.

    See Section II.

12. Check oil level.

    See Section III.

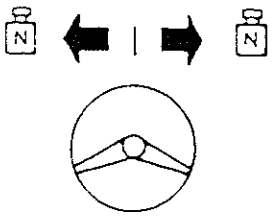
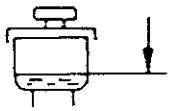
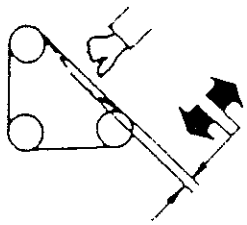
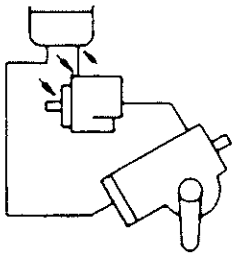
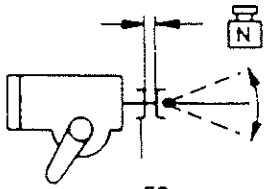
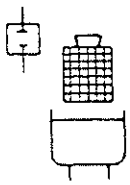
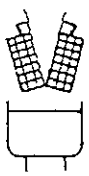
XI. Troubleshooting

ZF hydraulic power steering systems have been developed for heavy use. They are constructed so that no malfunctions can occur with perfect maintenance and under normal operation.

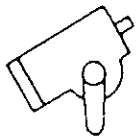
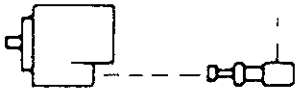
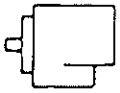
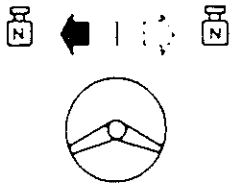
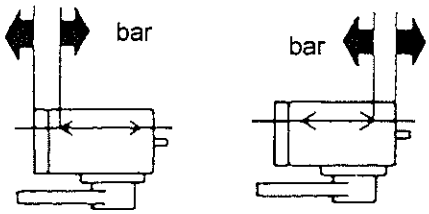
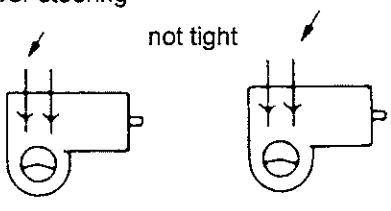
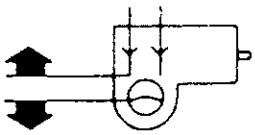
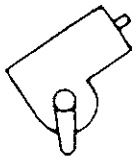
However, if this should not be the case, the following information should help locate and eliminate any problems.

Before examining the steering system for the individual faults, check the oil level with the engine running. The exact procedure for oil filling is described in detail in a separate section.

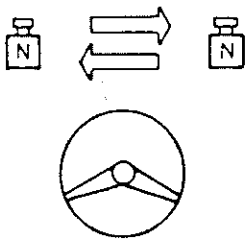
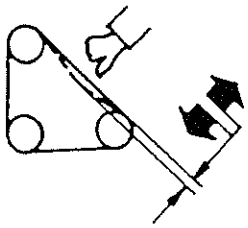
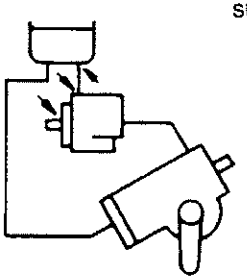
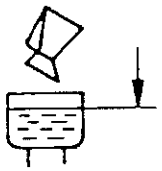
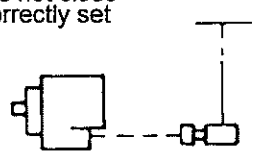
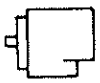
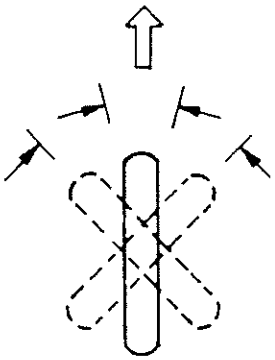
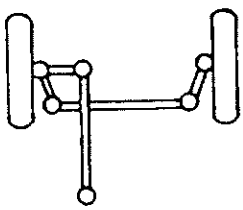
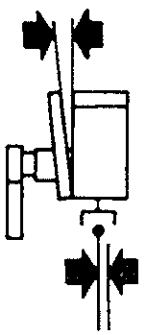
We must also point out that the use of very frothy oils can lead to faults, since such oils can only release air with difficulty, or not at all, once it has penetrated the steering system.

Fault	Cause	Remedy
heavy on both sides 	 min.	eliminate leakage
		max.
		tension V–belt [1]
		replace seals [1]
		max.
		ventilate
	 53	grind off / replace [1]
	 contaminated/ broken	replace, clean control valve, suction line
		replace, clean control valve, suction line

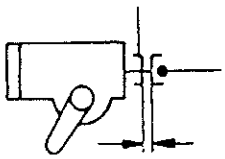
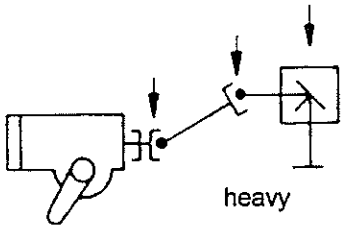
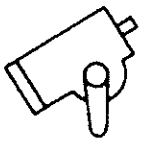
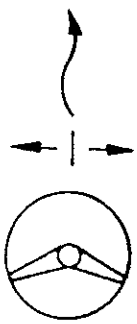
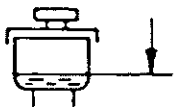
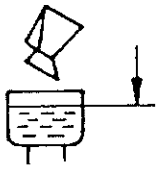
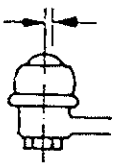
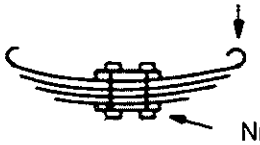
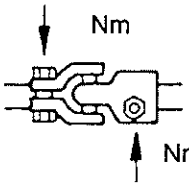
[1] refer to instruction of vehicle manufacturer

Fault	Cause	Remedy
	 internal fault	— exchange steering [1]
	does not close – incorrectly set  729	clean replace
	 internal fault	— exchange pump [1]
heavy on one side 	Servocom  bar bar	— set section II
	Recirculating ball power steering  not tight 53 54 55	— replace
	bar 	— set section II
	 internal fault	— exchange steering [1]

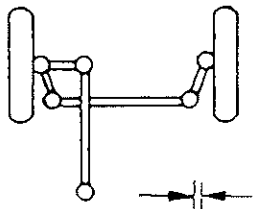
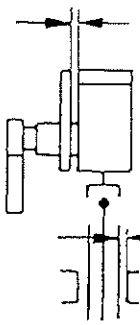
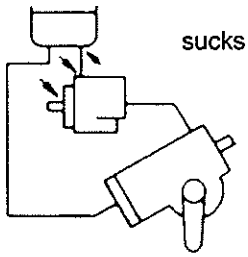
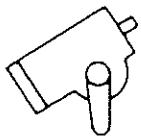
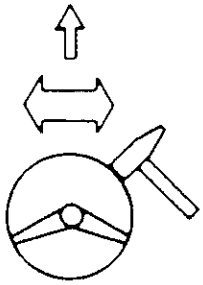
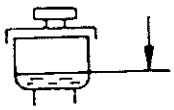
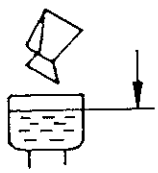
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
heavy on quick steering 		tension V–belt [1]
	sucks in air 	replace seal  max. ventilate
	does not close – incorrectly set  729	clean replace
	 internal fault	exchange pump [1]
inhibiting return V (km/h) 	 heavy	lubricate [1]
	distorted 	loosen bracing [1]

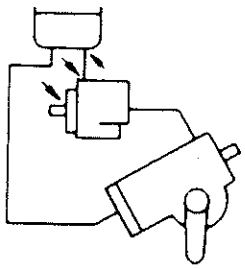
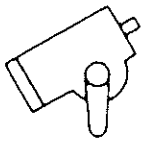
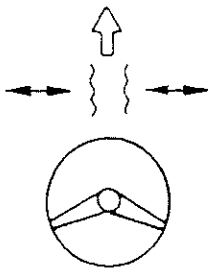
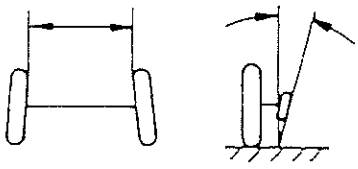
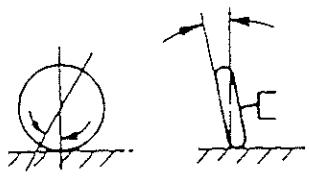
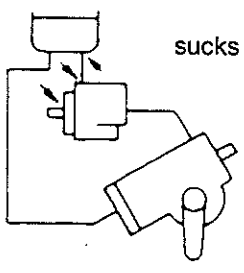
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	53  sticks	grind off / replace [1]
	 heavy	lubricate / replace [1]
	 internal fault	exchange steering [1]
not exact V (km/h) 	 min.	eliminate leakage
	 max.	ventilate
		
	 Nm	tighten / exchange [1]
	 Nm Nm	

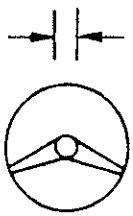
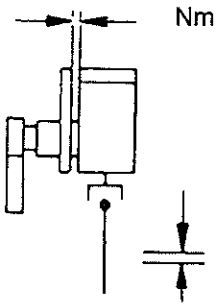
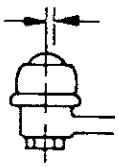
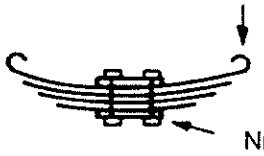
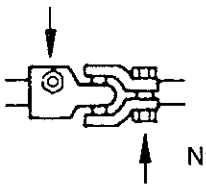
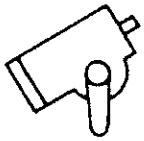
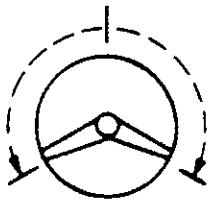
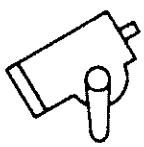
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	 heavy	lubricate [1]
	Nm 	tighten [1]
	Nm	
	 sucks in air	replace seals ventilate
	 internal fault	exchange steering [1]
steering wheel locks V (km/h) 	 min	eliminate leakage  max.
	free play 	replace [1]

[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
	 sucks in air	replace seals ventilate
	 internal fault	exchange steering [1]
torsional vibrations V (km/h) 	 imbalance	balance [1]
	 	set [1]
	 sucks in air	replace seals ventilate

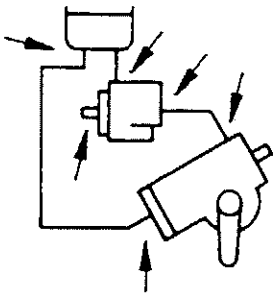
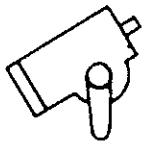
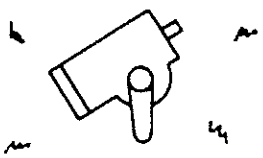
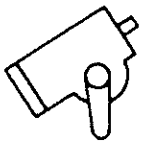
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
play in steering wheel 	 Nm   Nm Nm  Nm  internal fault ——	tighten / replace [1] exchange steering [1]
runs out 	 internal fault ——	exchange steering [1]

[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
noises	sucks in air	replace seals
		max.
		ventilate
	min.	eliminate leakage
	pressure line	max.
		rubber retainer [1]
	min. 0.85 bar	ZF service agency
loss of oil		close
min.	616	replace
	617	

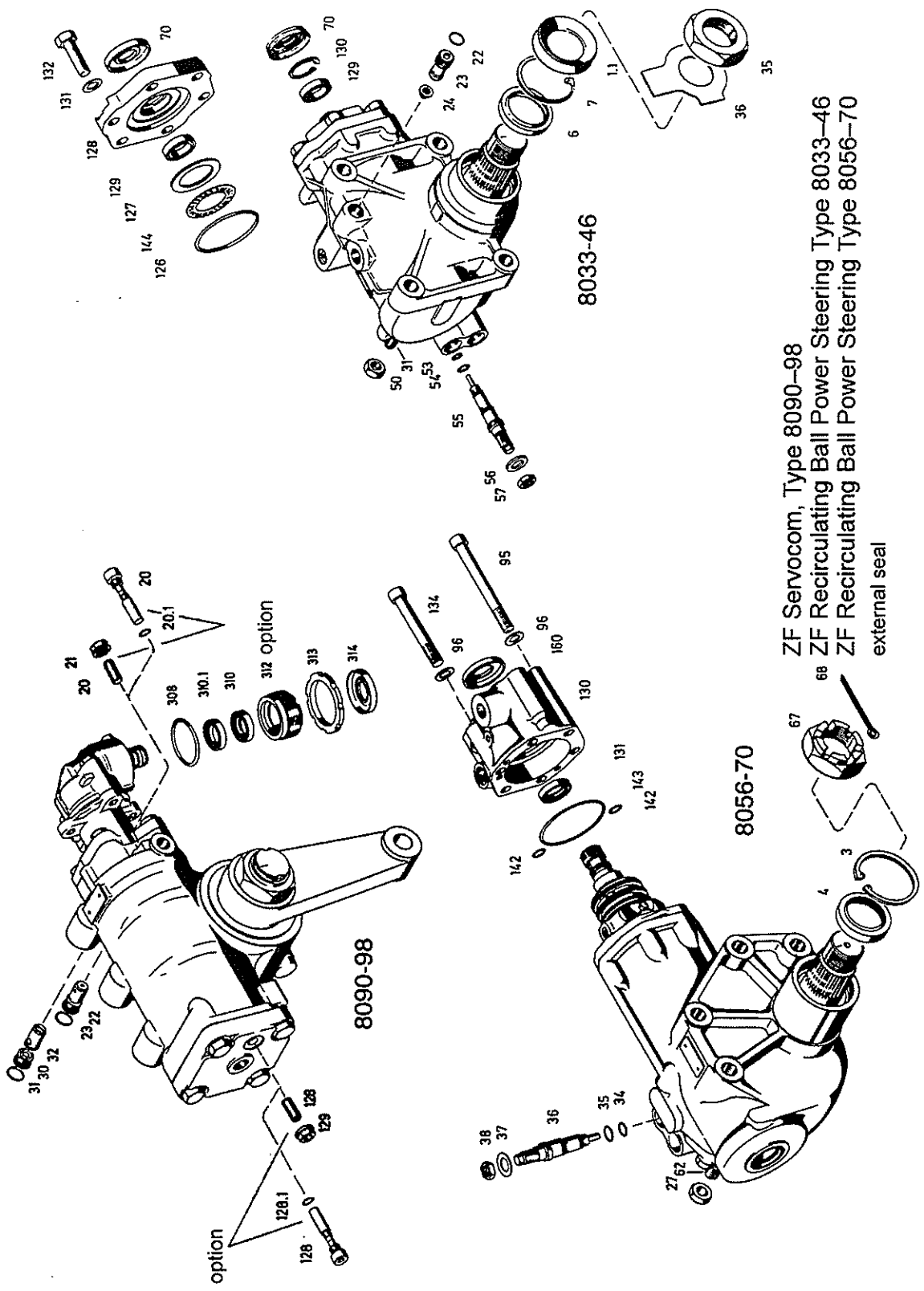
[1] refer to instructions of vehicle manufacturer

Fault	Cause	Remedy
		replace seals tighten lines
	 internal fault	exchange steering [1]
noises 	 internal fault	exchange steering [1]

[1] refer to instructions of vehicle manufacturer

XII. Key to numbers in illustrations and exploded views

1.	Housing
1.1	Dust seal
3	Circlip / Locking ring
4	Shaft seal
6	Shaft seal
7	Circlip / Locking ring
20	Stud / screw
20.1	O–ring
21	Flanged nut / Collar nut
22	Pressure control valve
23	O–ring
24	Screen filter
27	Hexagon nut
30	Screw
31	O–ring / Adjusting screw
32	Feeder valve / Suction valve
34	O–ring
35	O–ring
36	Valve accessories
37	Washer / Disk
38	Hexagon nut
50	Grommet nut
51	Dust seal
53	O–ring
54	O–ring
55	Valve
56	Washer / Disk
57	Hexagon nut
62	Adjusting screw
70	Protective cap
95	Cheese head screw
96	Washer / Disk
122	Intermediate cover
126	O–ring
127	Bearing plate
128	Stud / Cover / Screw
128.1	O–ring
129	Flanged nut / Collar nut
130	Valve housing / Circlip / Locking ring
131	Washer / Shaft seal
132	Hexagon screw
134	Cheese head screw
142	O–ring
143	O–ring
144	Thrust needle cage / Axial needle cage
151	Valve body
152	Valve spring
153	O–ring
154	Setting plate / Adjusting plate
155	Valve guide
156	O–ring
157	Circlip / Locking ring
158	Plug screw
160	Protective cap
306	Bevel gear wheel
308	O–ring
310	External shaft seal
310.1	Internal shaft seal
312	Adjusting screw
313	Slotted nut / Grooved nut
314	Protective cap


ZF Servocom, Type 8090–98
ZF Recirculating Ball Power Steering Type 8033–46
ZF Recirculating Ball Power Steering Type 8056–70
external seal
8033-46
8056-70
8090-98
option
option

Notes

Notes

Notes